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Agricultural engineering in development

Intermediate blacksmithing: a training manual

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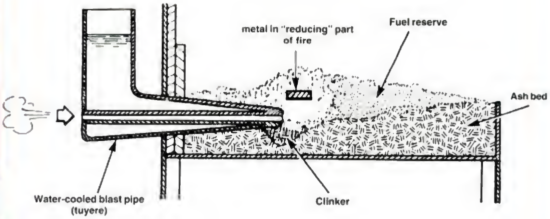
88/2

BLACKSMITH'S FIRE


metal in "reducing" part of fire
Fuel reserve
Ash bed
Water-cooled blast pipe (tuyere)
Clinker

Food
and
Agriculture
Organization
of
the
United
Nations

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Intermediate blacksmithing: a training manual

by
J.B. Stokes

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Preface

As with the previous volume, *Basic blacksmithing*, all practice jobs described here have been well tried and tested. Again, this second volume is intended to help instructors who are training blacksmiths for work in rural areas in developing countries. The contents are not intended to be lesson plans, which should be the responsibility of the instructors themselves. I have assumed, for the purposes of this book, that the more modern welding processes (oxyacetylene and arc) are not available. If the techniques in *Basic blacksmithing* have been mastered, the work explained here should not present major difficulties.

As with *Basic blacksmithing*, all sizes for materials are for guidance only and will usually depend upon the materials available. Tools should always be of a size found most useful to the blacksmith and will be influenced by the kind of work undertaken. Good hammers, effective tongs and good sets are essential to efficient work. The need for fullers, swages, set hammers and flatters will again depend upon the jobs undertaken and the standard of finish required.

Blacksmithing should not be considered as an end in itself but rather as a starting-point for the repair and maintenance of agricultural tools and equipment and possibly for small-scale manufacturing. Where power supplies are reliable, more modern techniques should be introduced when possible. Blacksmithing is a traditional and relatively low-cost method of dealing with the problems of farm work, particularly in areas where machine shops are rare.

J.B. Stokes

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Contents

Preface iii

PRACTICE JOBS

1. FORGING A WELDED EYE-BOLT 2
2. ALTERNATIVE METHOD OF FORGING AN EYE-BOLT 4
3. BUTT-WELD USING A CLEFT PREPARATION 6
4. RIGHT-ANGLE WELDED JOINT, USING A CLEFT PREPARATION; FORGING A BENDING DOG 8
5. POCKET OR CLEFT METHOD OF MAKING A T-SHAPED JOINT 11
6. CORNER WELD IN FLAT MATERIAL WITH DIAGONAL SCARF 13
7. FORGING A U-SHAPED BOLT WITH SHARP INSIDE CORNERS 16
8. FORGING A REINFORCED CORNER 19
9. FORGING BLACKSMITHS' TONGS 21
10. SHOULDERING-DOWN TO FORM TENONS AND ROUND-SECTION PEGS OR RIVET ENDS 30
11. THE EASIEST WAY TO FORGE HOT AND COLD SETS 34
12. FORGING FULLERS AND TOOL-HOLE SWAGES FROM SCRAP MATERIALS 38
13. FORGING TOP AND BOTTOM SWAGES 42
14. FORGING SET HAMMERS AND SIDE SETS 46
15. FORGING A FLATTER 49
16. FORGING A SIMPLE BALL-PEEN HAMMER 51
17. FORGING AN ENGINEER'S BALL-PEEN HAMMER 54
18. SOME APPLICATIONS OF CAST IRON AS A HARD-FACING MATERIAL 57

GLOSSARY 59

Practice jobs

1. Forging a welded eye-bolt

FIGURE 1

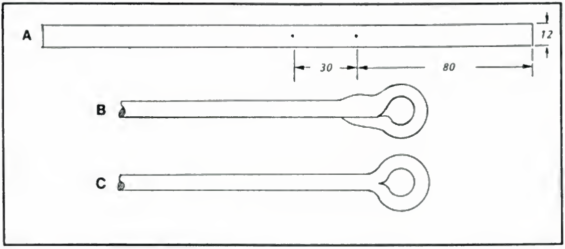
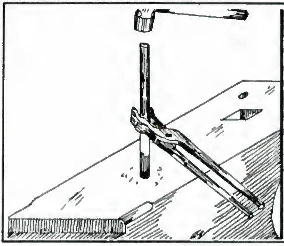


FIGURE 2



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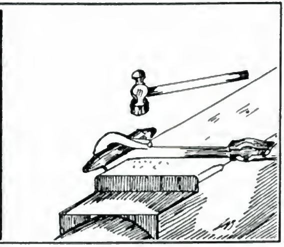


FIGURE 4

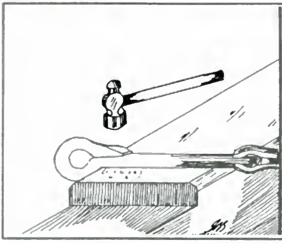
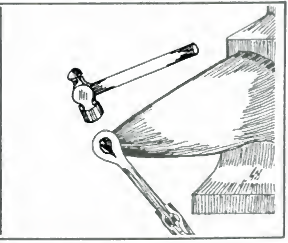


FIGURE 5



Material. Mild steel, 12 mm in diameter; a hand length or a piece 220 mm long, as desired.

Additional tools. A 14-mm drift; hole gauge; 12-mm screwing dies.

METHOD

Eye-bolts (Fig. 1C) are required for many applications. Unwelded eyes are good enough for some purposes, but a welded eye is stronger. Examples of uses include: spike-harrow spreader bars, door fixings, gate fixings, ox-carts and ploughs.

Mark off the metal (Fig. 1A). Take a near-welding heat between the marks, restrict the heat to this area by cooling adjacent metal with water and upset until the diameter is increased by about 3 mm. Take a near-welding heat and forge an abrupt, one-sided point on the end of the piece. In the same heat, bend the end around the drift (Fig. 3) to give the shape shown in Fig. 1B.

Take a full-welding heat and weld (Fig. 4), making use of the rounded edge of the anvil. Do not use a swage for this unless it has well-radiused edges. True up the eye over the beak (Fig. 5). If a square shank is required, merely upset a little more and leave a square section under the eye after welding. Eye-bolts with such a square section are used in wood to prevent their turning.

It is important to true up with accuracy the end to be threaded. Use a hole gauge to check the size.

2. Alternative method of forging an eye-bolt

Material. 140 mm of 12-mm diameter bar and a hand length of the same material.

Additional tools. A 30-mm diameter drift.

METHOD

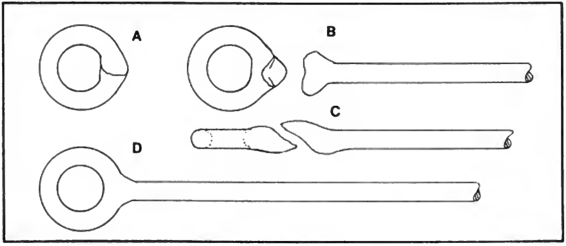
This method is useful for making heavier eye-bolts and similar items with large-diameter eyes. For practice, again use a 12-mm diameter bar, but you may try heavier sizes if you want to. Figure 6 illustrates the production steps but leaves all dimensions optional. Assume an eye with an internal diameter of 30 mm. Calculate the amount of metal needed to form the eye and cut off that amount.

Calculation

Inside diameter of ring= 30 mm
Mean diameter of ring = 30 ± 12 mm = 42 mm
Metal required = 42 x 3.14 ± metal thickness x 2
42 x 3.14 ± 24
= 131.88 ± 24 = 155.88
= approximately 156 mm

Cut off metal required, heat and upset both ends, bend and adjust (Fig. 7). Scarf in the manner used for a chain link, using the edge of the anvil or a small fuller. Close up and fix the position of the scarfs (Fig. 8). Take a full-welding heat and weld (Figs 9 and 10), leaving surplus

FIGURE 6



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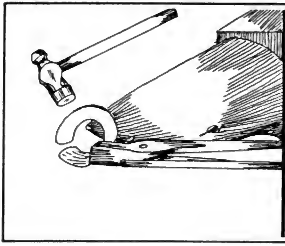
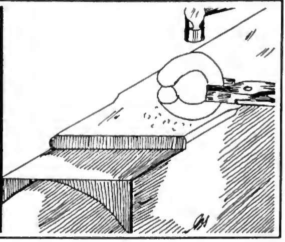


FIGURE 8



material slightly pointing outward from the eye (Fig. 10).

The welded joint is then scarfed over an edge of the anvil to give a V-shaped indentation (Fig. 6B). The hand length is then upset and scarfed (Figs 6B and C). Take a full-welding heat on both scarfs, position (Fig. 13) and weld with light, rapid hammer blows.

Reheat and make final adjustments to the workpiece. Cut the shank to length and check the end diameter for threading. Use a hole gauge to ensure that the diameter is accurate. Heat to a dull red heat all over, clean with a wire brush and allow to cool in the air.

Take care to leave the junction of the shank and the eye well-radiused (Fig. 6D). Do not use a swage unless it is well-radiused to give the correct section. The eye may be rounded up by using a 30-mm drift or gently working the piece around the beak.

FIGURE 9

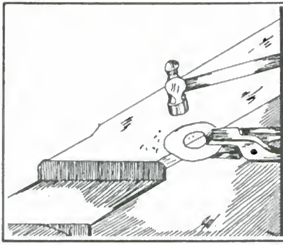


FIGURE 10

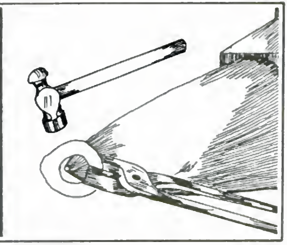


FIGURE 11

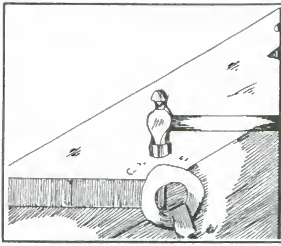


FIGURE 12

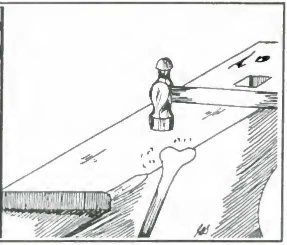
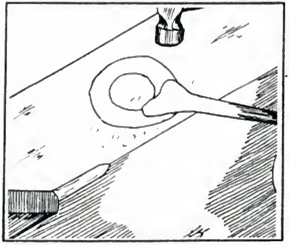


FIGURE 13



3. Butt-weld using a cleft preparation

Material. Mild steel, 25 mm or more in diameter; two hand lengths or one hand length plus a piece about 150 mm long.

Additional tools. Sharp hot set or hot chisel; suitable top and bottom swages if using round section; flatter and set hammer may be useful.

METHOD

This method is generally used for heavier sections of 25 mm and above; other-than-round sections can also be welded this way.

Preparation is shown in Fig. 14. Both pieces are upset to give about a 25 percent increase in diameter. After some practice, a smaller amount of upset will be sufficient. One piece is slightly flattened and cut (Fig. 15) and the cut is opened out (Fig. 16). This piece is placed near the fire to keep hot while the other piece is drawn-down to an abrupt point (Fig. 17). Placed in a clean fire, both pieces are brought to a full-welding heat, put across the anvil and hammered to force them together (Fig. 18).

Slow heating is required on heavy sections to ensure that the heat soaks through the whole thickness of the metal. An increase in air blast, to speed up heating as welding heat is approached, is recommended.

If no helper is available, one piece can be placed vertically in a swage block, through the tool hole of the anvil or in any other suitable support. The other piece

FIGURE 14

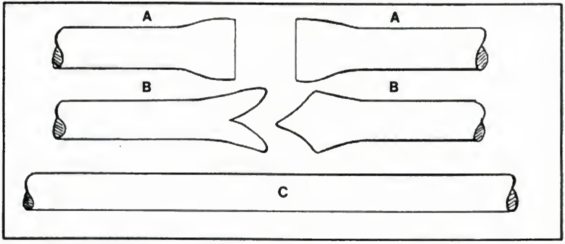


FIGURE 15

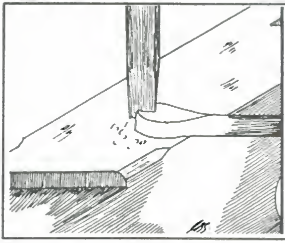
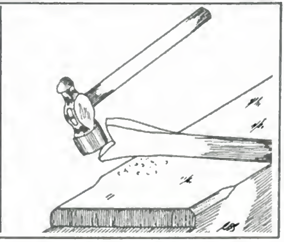


FIGURE 16



would then be placed in position and driven into the opposing piece.

Take a second welding heat and forge the job to a square (Fig. 19). This square section should be near to the finished-diameter size. If necessary, take an additional heat before forging to the hexagonal section (removing corners). Round up as well as possible, using a flatter and rotating the work as necessary before final finishing in top and bottom swages.

Heavier sections can be upset by lifting and dropping on to the face of the anvil, using the weight of the material to do the upsetting. If the anvil is too high for the smith to carry this out, the upsetting can be done on a swage block or any other block of suitable size placed on the floor. Another method, which requires a little less energy, would be to swing the bar horizontally in to the side of the anvil or swage block. In other cases it may be necessary to lay the heated bar along the long axis of the anvil and get the helper to hammer the end by swinging the sledgehammer horizontally. This is, however, a very tiring way of using a sledgehammer.

FIGURE 17

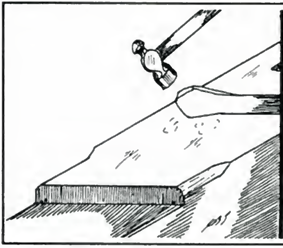


FIGURE 18

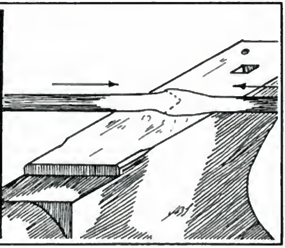


FIGURE 19

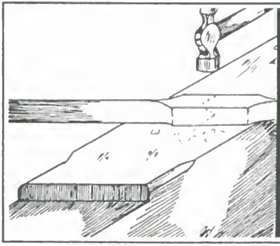
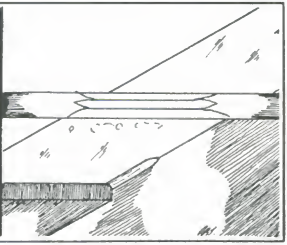


FIGURE 20



4. Right-angle welded joint, using a cleft preparation; forging a bending dog

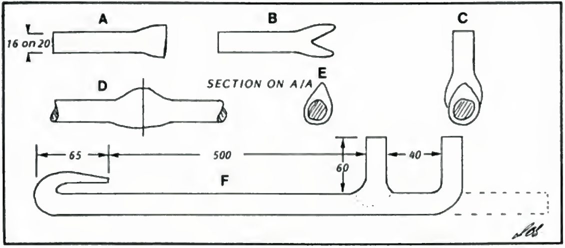


FIGURE 21

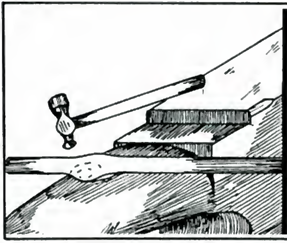
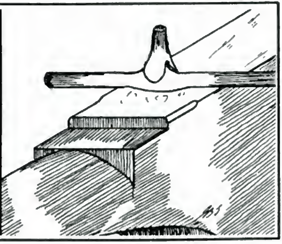


FIGURE 22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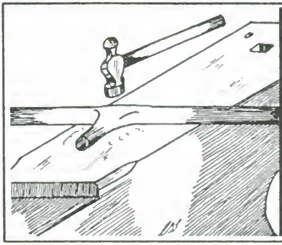


FIGURE 24

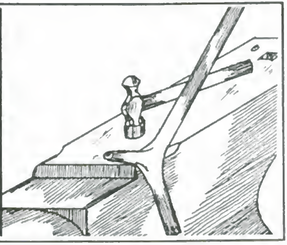


FIGURE 25

Material. Round section of mild steel 16 to 20 mm in diameter and 700 mm in length.

Additional tools. Bottom swage to suit diameter of metal used; hot set or chisel.

METHOD

This workpiece shows another use for the cleft preparation and at the same time will produce a tool useful for many bending and adjusting jobs. It is a good idea to have several such tools of different sizes.

Cut off a piece of metal 100 mm long and upset (Fig. 21A). This is then split with a hot set or hot chisel as in the previous job and formed to shape (Fig. 21B). Make a prominent centre-punch mark 140 mm or so from one end of the other piece. Heat to a near-white heat at this mark, cooling with water to control the length of the heat, which should be only about 40 mm and upset to gain 3 or 4 mm on the diameter at this point (Fig. 21D).

Reheat to a yellow heat and scarf using the ball of the hand hammer while working over the beak (Fig. 22). Heat both pieces and make sure that they are a snug fit (Fig. 23). Bring to a full-welding heat and weld together, beginning with a position where the smaller piece is driven down on to the longer one (Fig. 23). Additional hammering is then carried out, working alternately from each side (Fig. 24).

If necessary, take another welding heat and complete the joint, making sure that both scarfs are securely welded into a solid mass. Slightly bend the longer part (Fig. 25) and complete the finishing in the position shown. Forge to a square section first, remove corners and then finish to a round section with the hand hammer.

It is important that a well-pronounced radius be maintained at the junction of the two pieces to give it strength. Careful use of top and bottom fullers will help to form this radius and produce a neat finish. Top and bottom swages can be used to impart a better finish to the short arm after welding, but take care not to allow the edges of the swages to indent the radiused junction of the work.

FIGURE 26

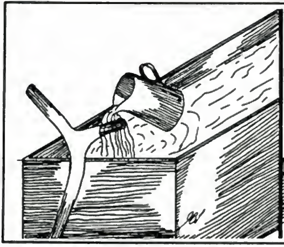


FIGURE 27

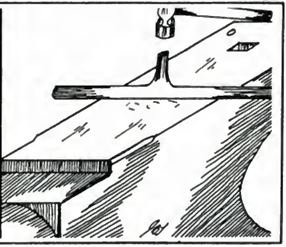


FIGURE 28

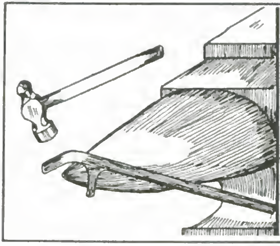
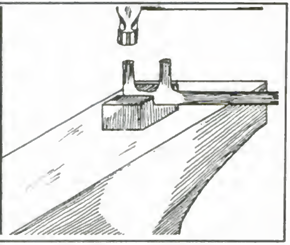


FIGURE 29



Reheat to a bright red heat, cool the short arm with water (Fig. 26) and then, by holding on the anvil (Fig. 27) and applying hammer blows to the short end, the long back part can be straightened.

Next, mark off the required length for the bend at the end of the long piece and cut off any excess with a sharp hot set. The length will depend on the thickness of metal to be bent with this tool, but for this example it will be about 150 mm. Lightly centre-punch this position and then heat to a bright red heat, cool with water to restrict the heat to within about 15 mm each side of the mark, bend over the beak (Fig. 28) and finish (Fig. 29) in a bottom swage. The workpiece can now be finally trued up in all directions and allowed to cool in the air.

The space between the two short arms now formed must be larger than the metal upon which the tool is to be used. With a space of 40 mm, metal with a thickness of 10 to 20 mm can be handled. Only a few such tools are needed to cover a very wide range of metal sizes.

The hooked end shown in Fig. 21F is next to be formed. Take a near-welding heat on the end of the bar and forge a flat point. Keep the width of the point to approximately the same as the diameter of the bar. This end is then bent back over the handle (Fig. 21F) and closed tightly on the piece of the metal it is to fit.

To complement this tool, a fork can be made to fit into the tool hole of the anvil. These tools are often preferable to a vice for bending work since they are faster to use than moving from anvil to vice and back again. Bending dogs can be made of steel from 10-mm rod up to 25-mm bar for heavy work.

5. Pocket or cleft method of making a T-shaped joint

Material. Flat section mild steel as available; for practice, metal of about 30 x 10 or 12 mm is suggested, one piece 250 mm long and another about 150 mm long.

Additional tools. Sharp hot chisel with a curved cutting edge.

METHOD

This preparation in flat section steel produces the strongest T-shaped joint (Fig. 30). Bring the centre section of the longer piece to a good yellow heat, cool with water to restrict the heat to a length of about one-and-a-half times the width of the bar. Upset until the metal is 25 to 50 percent thicker than its original size. Keep the extra metal to one side by working over the tool hole of the anvil (Fig. 31). Thin down the upset edge a little (Fig. 32), then split it with a hot chisel (Fig. 33) to form a cleft with two lips.

Next, take the shorter piece, upset one end and draw down to an abrupt flat-edged point (Fig. 34). Heat the longer piece and then drive the point of the short one in to the cleft in the longer piece (Fig. 35), close the lips on to it, then separate the two pieces. At this stage it is a good idea to spend a little time practising taking the pieces from the fire and rapidly positioning them for

FIGURE 30

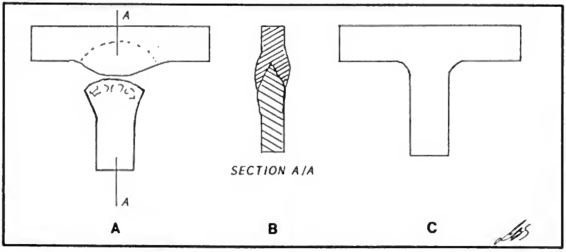


FIGURE 31

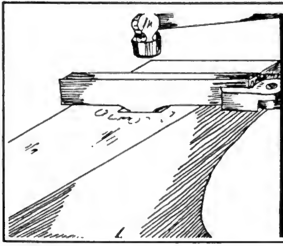
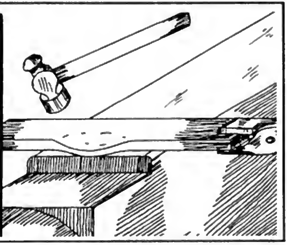


FIGURE 32



welding. The longer piece must be placed on the anvil face with the cleft uppermost, and the prepared end of the other presented vertically and inserted into the cleft. This must be done quickly.

Take a full-welding heat on both pieces, heating slowly at first to ensure even heating. Remove from the fire, quickly tap the longer piece on the anvil with the cleft downwards to remove dirt and oxides, quickly invert it on to the anvil face, position the shorter piece and drive it into the preparation with quick, light hammer blows (Fig. 35). If necessary, take a second welding heat and, working from both sides, weld in the lips of the scarfs (Fig. 36).

If there is more metal at the joint than can be easily worked in after welding, a small half-round chisel may be used to trim away the excess in the corners. Work from both sides to leave a neat radius. If a helper is available, a flatter may be used to improve the finish.

FIGURE 33

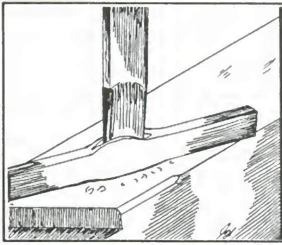


FIGURE 34

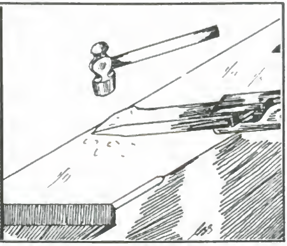


FIGURE 35

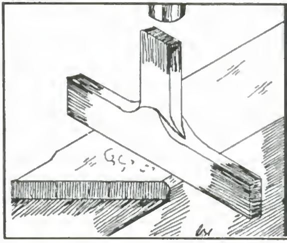
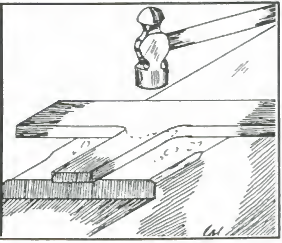


FIGURE 36



6. Corner weld in flat material with diagonal scarf

FIGURE 37

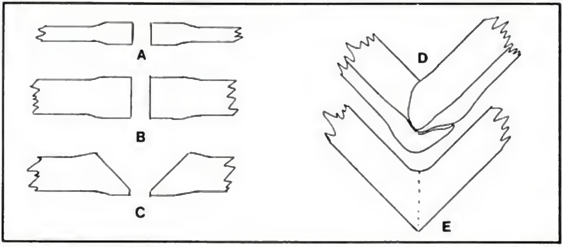


FIGURE 38

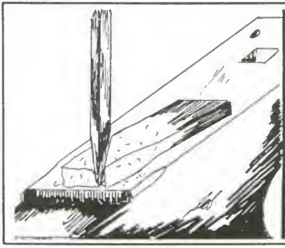


FIGURE 39

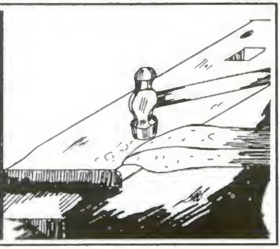


FIGURE 40

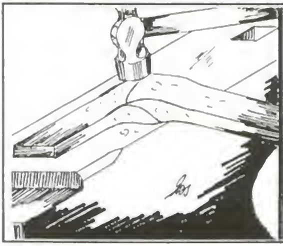
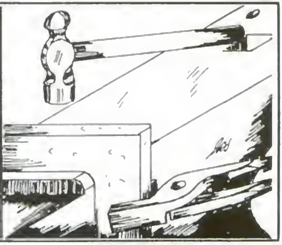


FIGURE 41



Material. Flat mild steel as available; for practice, material about 30 x 12 mm is the easiest to handle; two pieces about 150 mm long may be used.

Additional tools. Half-round hot chisel of 6-mm radius; if a helper is available, a flatter and a 12-mm top fuller, hot set or chisel.

METHOD

Where sharp angles in flat material are required, it is often quicker and easier to make a corner weld rather than to make the corner from one length. Although the job described and illustrated is a right-angle corner, other angles can be produced in a similar manner. Both pieces are upset (Fig. 37A). The amount of upsetting depends to a large extent upon the skill of the smith but, as an example, 12-mm bar would be upset to about 14 mm in thickness. Pieces are then heated and cut with a sharp hot set or hot chisel (Figs 37C and 38). In this case the cuts are at an angle of 45 degrees to the centre line of the metal.

Cut the angles from one side, thus leaving bevelled ends that facilitate the scarfing. Scarfing can be carried out as in Fig. 39 or by using a fuller instead of the edge of the anvil. Now decide the best position on the anvil for the initial welding and mark a right angle with chalk. This will be a guide for placing the pieces correctly. Bring both pieces to a full-welding heat, position (Fig. 40) and apply quick, light hammer blows to weld the joint. If the position shown in Fig. 40 suits the smith, this is where the chalk marks should be made.

Hammer blows must be applied quickly to both sides, working from the centre outwards to expel slag and to ensure that the scarfs are properly welded. One heat should be sufficient but a second may be necessary. Flatten the metal to its original thickness and true up the angle, checking with a square and working surplus material toward the inside of the corner. Trim off surplus material with the half-round hot chisel to leave a pronounced radius inside the corner. If work is needed on the outside of the angle, use the radiused edge of the anvil (Fig. 41) to preserve the inside corner.

FIGURE 42

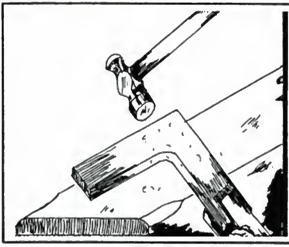


FIGURE 43

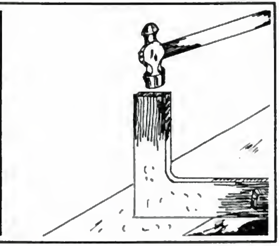


FIGURE 44

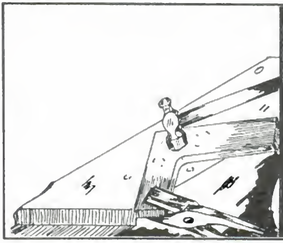
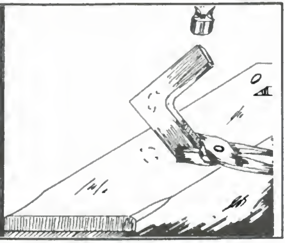


FIGURE 45



Most finishing and trueing up should be carried out as in Figs 42, 43, 44 and 45. Try to avoid working over the edge of the anvil.

When adjusting the angle, remember that stretching the inside of the corner will open the angle, while hammer blows on the outside corners (Fig. 45) will close it up. Figures 42 and 43 illustrate a corner being squared up while at the same time surplus metal is being worked into the workpiece to leave clean square edges on the outside. Stretching the inside of the corner is shown in Fig. 44.

7. Forging a U-shaped bolt with sharp inside corners

FIGURE 46

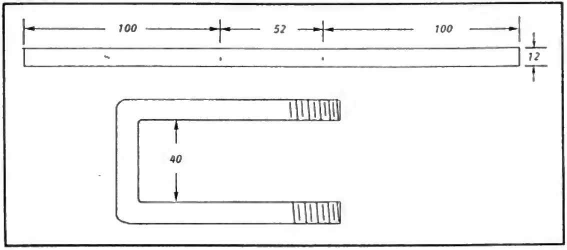


FIGURE 47

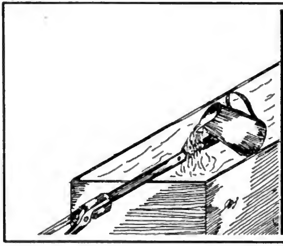


FIGURE 48

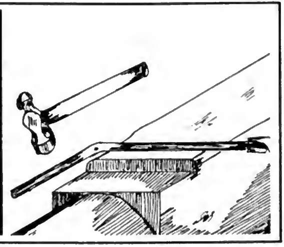


FIGURE 49

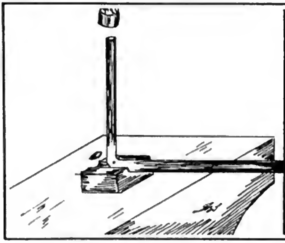
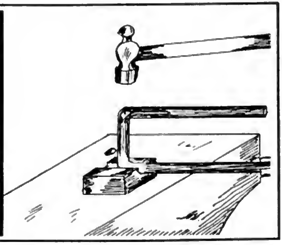


FIGURE 50



Material. Mild steel of suitable diameter for the load to be carried; for practice, 12-mm diameter rod is most suitable for use with ox-carts and similar applications; suggested practice length about 250 mm.

Additional tools. 12-mm diameter bottom swage; hole gauge; die stocks and dies for threading.

METHOD

These bolts are often required when fixing cart or trailer axles to springs or directly on to a chassis. For this kind of bending it is usual to add half the thickness of metal to the workpiece to accommodate the inside dimension of each bend. The distance between the bends in this case is 40 mm. There will be two bends so we add a half-metal thickness for each: 0.5 x 2 = 1 metal thickness = 12 mm. Now we have as length 40 + 12 = 52 mm (Fig. 46). Cut off 252 mm of 12-mm diameter rod and mark off (Fig. 46) and centre-punch these positions on the same side of the rod. These marks must remain on one side of the job throughout the forging operations. Such marks will show where heating is to take place and can prevent the development of cracks in the bends.

Heat each end in turn and forge to an abrupt bevel on each end (not illustrated). Make sure that each end will pass through the 12-mm hole in the gauge.

Take a bright red to yellow heat on one of the marks; restrict the heat to 12 to 15 mm each side of the mark by cooling (Fig. 47). Quickly bend over the rounded edge of the anvil (Fig. 48) or over the beak.

Reheat again and restrict the heat to the corner by cooling. The radius of the bend can now be reduced by working in a bottom swage (Fig. 49). Blows of the hammer are applied to each end in turn, taking care to

FIGURE 51

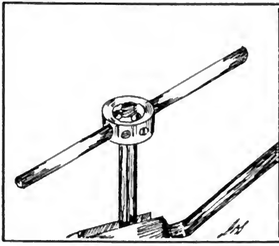
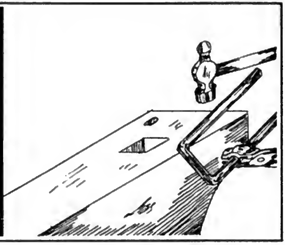


FIGURE 52



keep the centre-punch mark to one side (not the inside) of the centre of the bend. Take a heat on the other mark and repeat the procedure (Fig. 50). Take care with this second bend to direct the hammer blows correctly on to the bend already made; this will become easy after a little practice. Some slight unwanted bending usually occurs in the legs of the U and across the end, but this can be corrected later (Figs 52, 53, 54 and 55).

Take a heat in the centre of the U and twist the legs out of line with each other. Check again that the ends fit correctly in the hole gauge, correcting with a rasp while the piece is hot or with a file if it is allowed to cool. This will remove any slight increase in diameter caused by hammering on the ends. This final check is important as these ends must fit snugly in the hole gauge; too loose a fit will not allow enough material for the full depth of thread. After slow cooling, these ends are threaded using hand-held die stocks and dies (Fig. 51). Reheat the end of the U and twist back to the correct shape, set the sides parallel and gently flatten (Fig. 56).

Extreme care must be taken when working these corners in the bottom swage so that not even the slightest crack is allowed to appear on the inside of the bend. If a crack does occur, it is usually the result of leaving too much metal to be worked into the corner. If the bending heats are restricted close to the mark, a neat, strong corner will result.

This method of working gives bends with a pronounced outside radius but a very small radius inside the bend. Square-section material and some lighter flat sections can be bent to accurate dimensions using this technique. Where bends with a sharp outside corner and a pronounced radius inside the corner are required, other techniques must be adopted. Where U-bolts with pronounced radii inside and outside the corners are intended, the threading can be carried out before bending as no hammering on the ends is required.

FIGURE 53

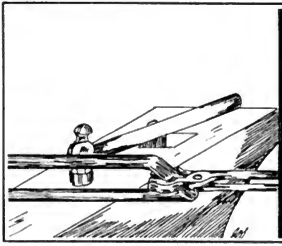


FIGURE 54

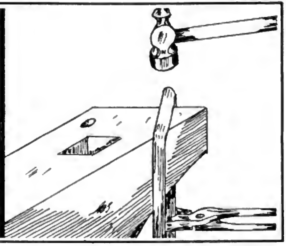


FIGURE 55

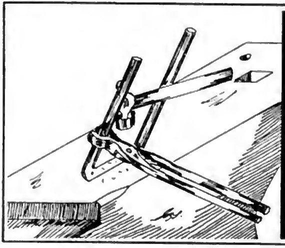
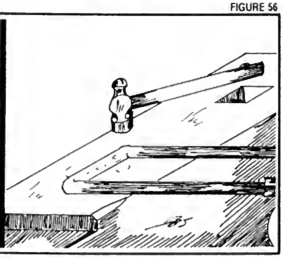


FIGURE 56



8. Forging a reinforced corner

Material. Mild steel 25 x 12 mm flat is suitable for practice, but any reasonable size will do.

Additional tools. None, but a flatter will give a better finish.

METHOD

Additional metal is required to form this kind of bend, and it is obtained by upsetting. It is usual to add a quarter of the metal thickness to the outside dimension for each bend (Fig. 57). The outside dimension is 120 mm and metal thickness is 12 mm, so 3 mm is added for each bend, making a total of 126 mm. The metal is then upset to one-and-a-half times its thickness where the bend is to be (Figs 57A and B). Cut off a piece of 25 x 12-mm bar 224 mm long. Lightly mark the centre of the length on one edge, then mark off 63 mm from the centre toward each end to give a total length of 126 mm in the centre of the piece. Centre-punch these positions on one edge of the bar (Fig. 57).

Heat the bar to a bright yellow heat in the position of the first bend and control the heated area by cooling to about 15 mm on each side of the mark (Fig. 58). Upset one end (Fig. 59). Take care to keep the swelling equal on both sides of the workpiece and do not allow bending to occur. Straighten any bending as soon as it becomes obvious. Upset the second bend position equally (Fig. 57B). Take a bright yellow heat in one bend position, control the length of the heat by cooling and bend over the beak (Fig. 60).

FIGURE 57

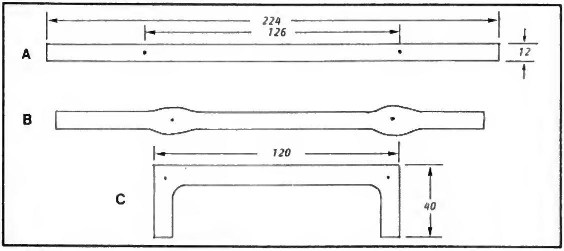


FIGURE 58

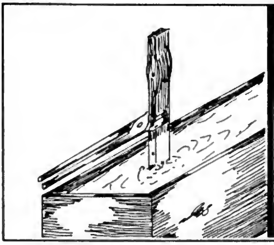
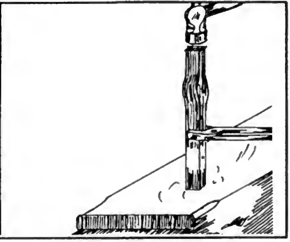


FIGURE 59



The bend should be as near to a right angle as possible. Additional heats and working (Figs 61 and 62) will complete the bend. Care must be taken to maintain a good radius inside the corner. Do not work over the edge of the anvil. Small adjustments can be made to the dimensions by either working more metal into the corner or drawing out a little as required.

The bending of the second corner is now carried out in a similar manner, taking care not to damage the corner already made. Next, correct any damage that might have occurred to the ends of the workpiece and, finally, true up the whole job. This kind of bend is used only when absolutely necessary because of the work and the time it requires. Wherever possible, radiused bends should be used. For smaller workpieces of this kind, it is often easier to start with oversized material and draw down, leaving extra metal for the bends rather than obtaining it by upsetting. If attempts are made to produce such bends without additional metal, cracking will occur.

FIGURE 60

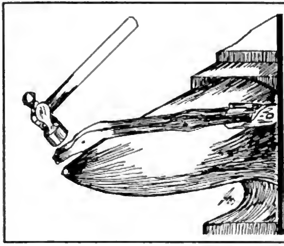


FIGURE 61

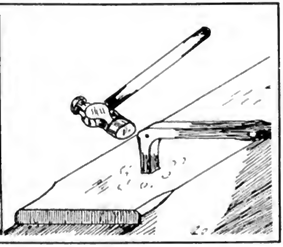
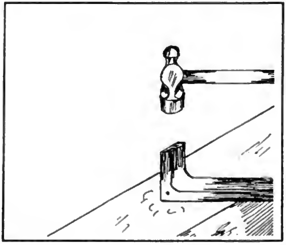


FIGURE 62



9. Forging blacksmiths' tongs

Material. Mild steel; for the bits (working ends), 22 to 25-mm round or square section, a hand length if possible; for bolt-tong bits, a hand length of 12 x 25-mm flat bar; for reins (handles), 8-, 10- or 12-mm rod; 8-mm rod for rivets.

Additional tools. Hand hammer; sledgehammer; hot set; set hammer; flatter; 12-mm top and bottom fullers; 25-mm top fuller; 25 to 26-mm bottom swage; punch for 8-mm holes; and a rivet snap to form rivet heads.

METHOD

The tongs described in *Basic blacksmithing* are not the best for heavy and prolonged work. A better tool is obtained from forging the bits by drawing-down from solid metal without the twisting described in Job 17 of *Basic blacksmithing*.

Tong bits as shown in Fig. 63 will last much longer and stand up to readjustments for various jobs. All tongs must fit well on the workpiece. Poorly fitting tongs are dangerous and always make work more difficult. It is often necessary to make or alter a pair of tongs for a specific job. It is a good idea to have a few partly forged bits and reins in hand to save time when a pair of tongs is quickly needed. Figure 64 shows some of the more common tongs in use. Others are made or adapted according to the smith's own ideas or as demanded by a particular job. The range of tongs is almost endless; individual smiths will develop their own according to job requirements.

FIGURE 63

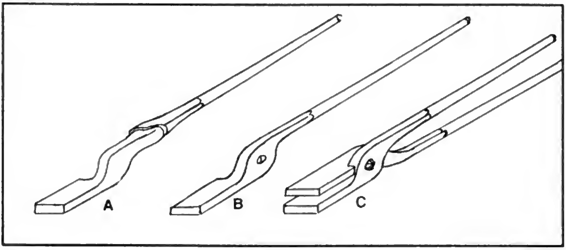
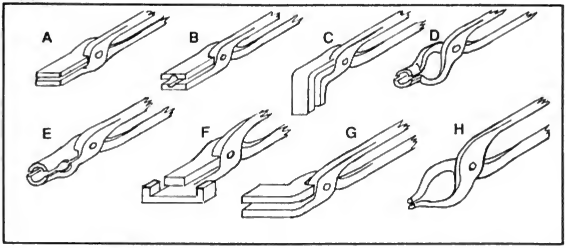


FIGURE 64



The common names for the tongs shown in Fig. 64 are:

A. Close bit tongs for holding thin flat sections.

B. Flat hollow bits for holding small flat and small round sections.

C. Flat-angle bits (sometimes called duck-billed) for holding flat and square sections on edge, such as rings, etc.

D. Bolt tongs for holding round sections with an obstruction at or near one end. They will, for example, fit over the head of a bolt to grip the shank of the bolt.

E. Combination hollow bits for holding round sections in two positions, to upset or to draw-down, for example.

F. Box bits can be made to hold heavier flat or square sections and help to prevent the workpiece from slipping sideways.

G. Side-angle bits are similar to C but are additionally useful for holding tools with eyes such as hammers, axes and sets.

H. Plier bits are useful for picking up hot pieces of metal to permit minor adjustments to workpieces.

To begin, cut off two pieces of bar 10 mm in diameter and 350 mm long. Round off one end of each to give a half-spherical shape. Upset the opposite ends and scarf for welding as in Job 17 of *Basic blacksmithing*. Put these two pieces – the reins – to one side until needed.

For the bit, take a welding or near-welding heat on a hand length of 12 x 25 flat bar for a length of 75 to 100 mm from the end. Place over the rounded edge of the anvil (Fig. 65) with about 50 mm lying on the anvil face and flatten, taking it down to a little over 8 mm in thickness but maintaining the width at 25 mm.

FIGURE 65

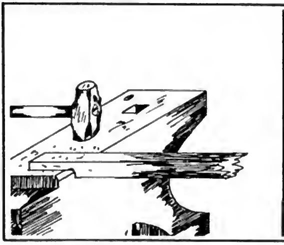
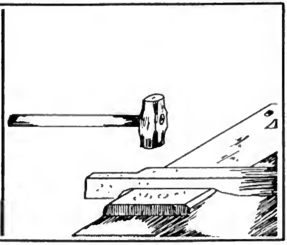


FIGURE 66



In the same heat if possible, turn the workpiece a quarter of a turn anticlockwise. Make sure that the anvil edge farthest away from the smith is exactly in line with the shoulder already formed. Flatten down (Fig. 66) to a little under 12 mm, allowing the metal to spread sideways without restraint. Again turn the job a quarter turn anticlockwise, allow 30 mm of the flattened metal to overhang the anvil edge and again flatten (Fig. 67). Another heat might be needed for this operation.

The metal is drawn-down until it is a little over 12 mm thick in the direction of working while being kept to a little under 12 mm in the other direction for a length of about 75 mm. At a distance of 75 mm from the last forged shoulder, the metal can be left up to 14 mm thick to save having to upset for scarfing. With a hot set, cut

FIGURE 67

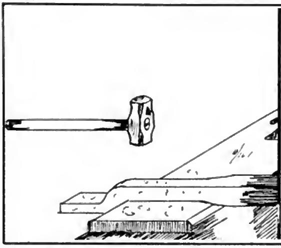


FIGURE 68

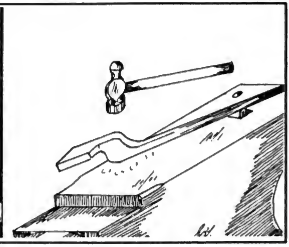


FIGURE 69

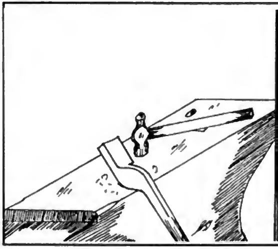


FIGURE 70

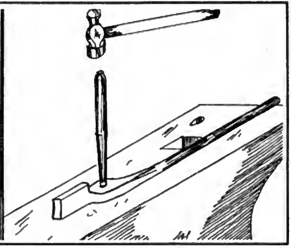


FIGURE 71

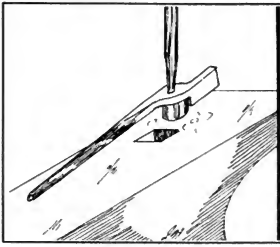
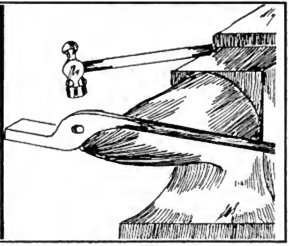


FIGURE 72



off the piece at the 75-mm mark. The bit end can now be held in tongs and scarfed (Fig. 63A). Make sure that the scarf is as shown.

The forged bit and one of the reins can now be welded together as for Job 17 of *Basic blacksmithing*. While still hot, the eye boss can be shaped (Figs 67 and 68). Reheat to a bright red heat and punch a hole 8 mm in diameter (Figs 70 and 71). Note that a small ring is used to support the eye (Fig. 71); an old nut of suitable size will pass neatly through this hole after punching and trueing up the work. The other half of the tongs is made in the same way.

After punching, the eye should be placed over the beak of the anvil (Fig. 72) and the bit bent or set down slightly to allow the reins to lie almost parallel when the tongs are assembled. Keep the bend close to the eye.

It is important to note that a good large radius must be maintained underneath the eye (Fig. 72) where the bits are drawn down to meet the reins. This part takes a great deal of strain when the tongs are in use.

For the rivet, a length of 8-mm rod is suitable and should be cut off 10 mm longer than the thickness of the two eyes. If the first eye plus the second eye = 16 mm, then the rivet length will be 16 mm plus 10 mm = 26 mm. The two halves of the tongs are placed together, then the rivet is inserted cold and lightly hammered from each side (Fig. 73). Make sure that an equal length of rivet protrudes from each side. This preliminary riveting keeps the rivet in place while the work is reheated.

The bit ends of the tongs holding the rivet are brought to a bright red heat, heating slowly to ensure that the rivet has sufficient time to heat up. Then the riveting is completed, working from alternate sides and using the ball-peen of the hammer.

After riveting, the tongs must be set to the metal they are to hold (Fig. 75). A piece of bar or a large drift is used to keep the reins apart during this operation. When set to the metal size, the reins should be a comfortable fit in the smith's hand, with little effort needed to hold the work firmly. Finally the reins should be smoothed with a file.

FIGURE 73

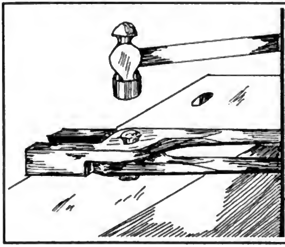


FIGURE 74

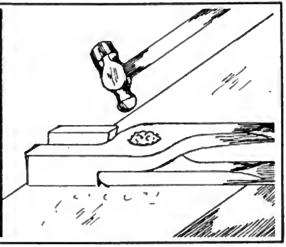
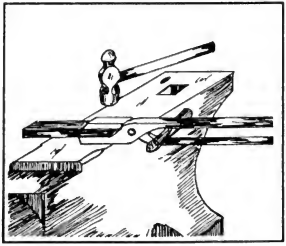


FIGURE 75



Box tongs (Fig. 64F) are made in the same way but with a crosspiece welded to the bits and then bent to shape.

Angled tongs (Figs 64C and G) are made in the same way with extra length allowed on the bits, which are then bent to shape.

The hollow bits (Fig. 64B) are again made in the same way. A piece of round-section metal is placed in the jaws while they are hot and the jaws hammered on to it to form the groove. A flatter may be used to do this.

The combination hollow bits (Fig. 64E) are formed (Figs 76 to 79) using a bottom swage and fuller. The fuller must be the same size as the bar to be held, while the swage must be large enough to accommodate the fuller plus twice the thickness of the jaws. It is usual to make the jaws thinner and wider than for flat tongs.

After riveting and setting to the metal thickness, the tongs are quenched in water while being rapidly opened and closed. This prevents the tongs from cooling off with the rivet too tight for the tongs to be operated. Tongs should open freely when the smith's grip is relaxed. It is worth repeating that tongs must be kept as cool as possible to avoid distortion or deformation while in use. If tongs do become damaged, they should be repaired immediately for the sake of safety and efficiency.

Figure 80 illustrates a completed side of a pair of combination tongs. The other side is identical, and riveting and setting are as described above.

Bolt tongs, plier tongs and variations of these are usually made in a slightly different manner. Additional tools needed are: a 12-mm top fuller, a 25-mm (or larger) top fuller and a bottom swage large enough to accommodate the diameter of bar the tongs are to hold plus twice the thickness of metal allowed for the working jaws (a swage of 25 to 26 mm). Figures 81 and 82 show the main forging steps to be carried out.

Figure 81A shows the fullering operations with the approximate spacing on the suggested metal size of 12 x 25-mm flat bar. Figure 81B shows the drawing-out result with a section at A/A formed as round as possible. This rounded portion is to allow the twisting

FIGURE 76

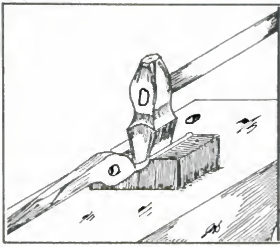


FIGURE 77

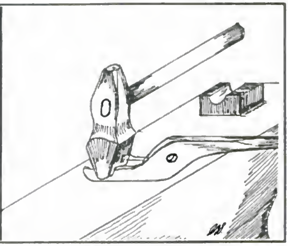


FIGURE 78

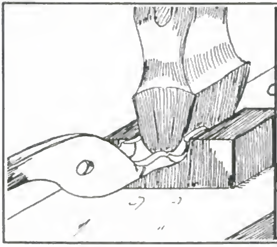
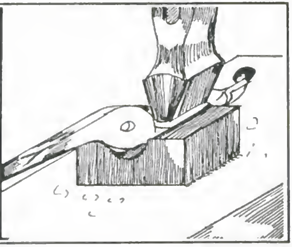


FIGURE 79



of the flat end to be carried out without sharp corners being left to work into the workpiece.

A and B of Fig. 82 illustrate the bending stages carried out to form bolt-tong bits.

Take a hand length of 12 x 25-mm flat bar. Place the bottom 12-mm fuller in the tool hole of the anvil and have the top fuller close at hand. Take a near-welding heat over about 75 mm along one end of the bar, place

FIGURE 80

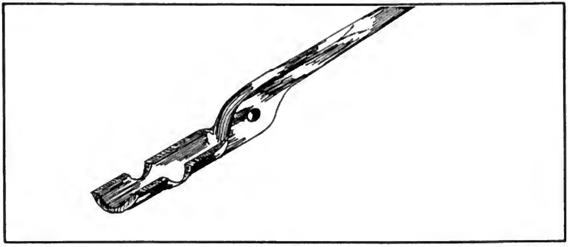


FIGURE 81

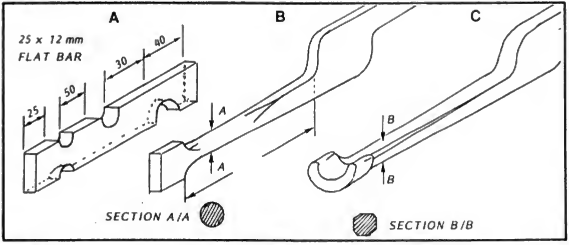
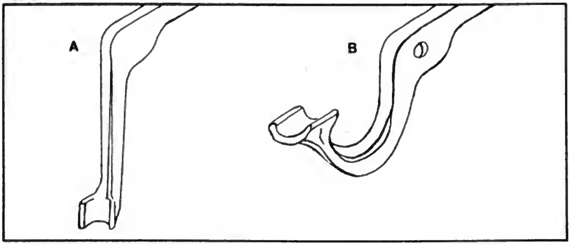


FIGURE 82



over the bottom fuller and position the top fuller (Fig. 83), estimating sufficient length to leave about 25 mm of the end of the bar unworked. Drive in the top fuller to a depth of 4 or 5 mm.

Turn the bar on to the flat face of the anvil and flatten it back to its original thickness with the hand hammer. Reposition the work between the fullers and drive them in to leave no more than 12 mm thickness in the centre.

Again flatten the piece back to its original thickness on the surface of the anvil. With quick movements, position the work and the top 12-mm fuller (Fig. 84), estimating or measuring with a metal rule the position of the fuller to leave 50 mm between the fuller grooves, as in Fig. 81A. Drive this fuller in to a depth of 12 mm. Flatten the piece to its original thickness with the work on its side. More light fullering might be needed to complete this operation. Next, mark the position of the 25-mm fuller groove with a centre-punch mark.

Reheat the metal and drive in the large fuller (Fig. 85) to a depth of 12 mm. Again, turn and flatten the work. Some fullering might again be needed after this

FIGURE 83

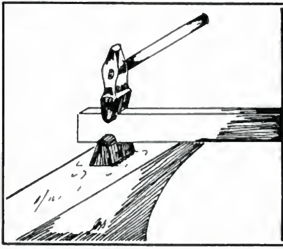


FIGURE 84

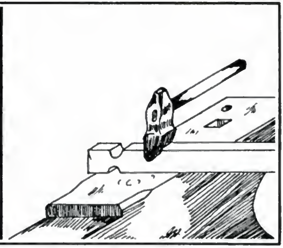


FIGURE 85

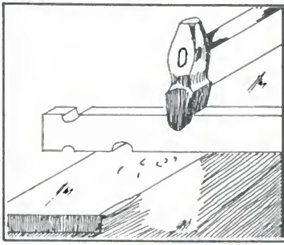
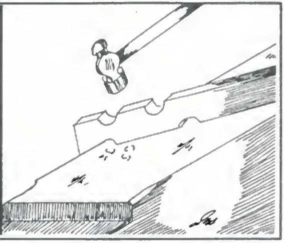


FIGURE 86



flattening. Next, begin drawing-down with the hand hammer (Figs 86 and 87), finishing as in Figs 87 and 88.

Note that this drawing-down is done to a square section after which the corners are removed (Fig. 88). With the hot set, cut off about 15 mm beyond the last fuller groove, draw-down to match the upset end of the reins and then scarf. See commencement of drawing-down in Fig. 89. Reins are now welded on, trued up and allowed to cool while the second side is brought to this stage. Next, flatten the end of the bit that is to form the nose to a thickness of about 6 or 7 mm while maintaining its width. Trim the end to length with the hot set, place in the large bottom swage and drive in the 12-mm fuller (Fig. 90). This forms the concave end.

Take a bright red heat close to the eye boss and cool the piece with water to restrict the heat to the eye-boss area. As shown in Fig. 91, the piece is placed on the anvil over the rounded edge of the anvil face, the helper holds it firmly with a sledgehammer and bending is started with the hand hammer. Bend as near as possible to the shape shown in Fig. 82A. Additional working

FIGURE 87

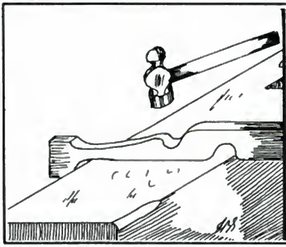


FIGURE 88

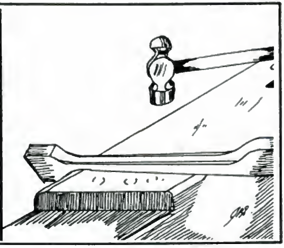


FIGURE 89

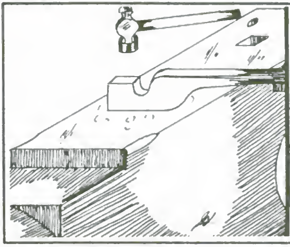
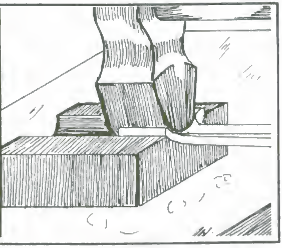


FIGURE 90



will be needed in most cases. Reheat and bend to the required curve (Fig. 92). Heat again close to the endpiece, cooling with water to restrict the heat to within about 15 mm of the formed end, and bend over the rounded edge of the anvil (Fig. 93). Punching, riveting and setting are next carried out as explained for flat tongs. Figure 94 is an illustration of completed tongs holding a bolt with clearance for the bolt head.

FIGURE 91

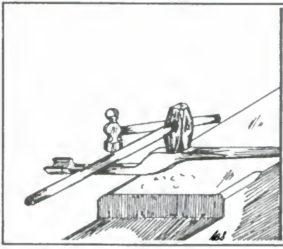


FIGURE 92

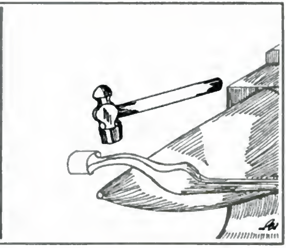


FIGURE 93

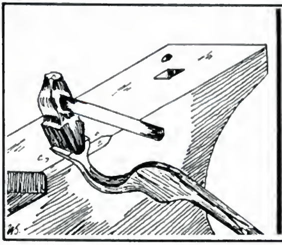
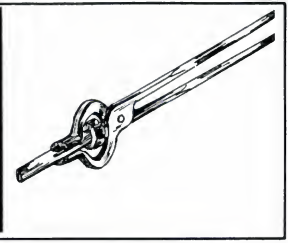


FIGURE 94



10. Shouldering-down to form tenons and round-section pegs or rivet ends

FIGURE 95

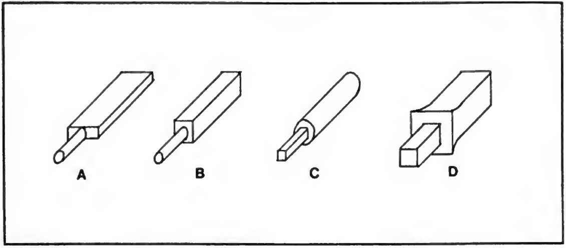


FIGURE 96

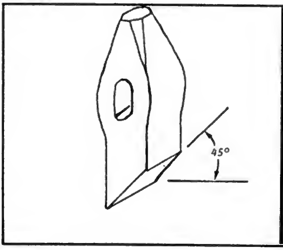


FIGURE 97

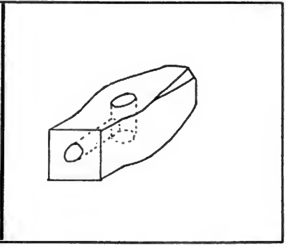
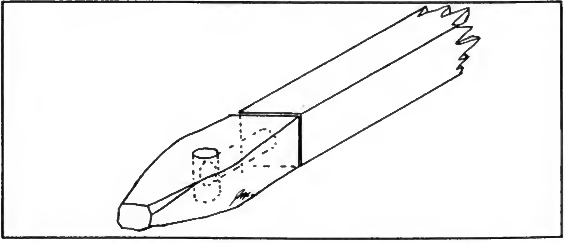


FIGURE 98



Material. Flat, square- and round-section mild steel as available.

Additional tools. Hot sets and hot chisel sharpened from one side only; side set; set hammer; top and bottom swages; a hole gauge; if desired, a monkey tool may be made but it is not essential.

METHOD

The blacksmith must often forge shoulders in the form of tenons, pegs and rivet ends for many applications. Some examples shown in Fig. 95 are: flat-to-round (A); square-to-round (B); round-to-square (C); square-to-square with upset shoulder (D).

Among the tools used for these operations are a side set (Fig. 96) and a monkey tool (Fig. 97). The side set is similar to a rather short, blunt hot set with one vertical face and another face at about 45 degrees to it with a small radius on the edge like a thin fuller. The monkey is essentially a block with two holes at right angles to each other and is used (Fig. 98) to finish and true up shoulders where the use of a bolster plate would present difficulties. One hole is the correct size for the peg end to be forged while the other provides clearance for the end of the peg end.

If used, monkeys are required in a number of sizes and the holes need to be drilled with the peg hole slightly countersunk where it will meet the shoulder.

To produce the type of peg end shown in Fig. 95A, the easiest method is to cut away the unwanted material, leaving a square shoulder, and then forge the peg. Some smiths prefer to use a hacksaw to cut away the surplus material. This takes more time but leaves neat and clean surfaces.

A good job can also be done by using a hot set or hot chisel sharpened from one side only and with a slightly blunted or radiused cutting edge like a very thin fuller. Carefully mark out the positions of the shoulders and, from the centre line, the width of the peg and then centre-punch these marks. Heat to a bright red heat and cut the shoulders from both sides nearly to the full depth (Fig. 99). Reheat if necessary and cut along the sides of the peg (Fig. 100), removing metal from both sides and leaving the centre part. This centre section is then forged to a square section (Fig. 101). A set hammer may be used close to the shoulder. Next, remove the corners (Fig. 102) to give an octagonal section. Finally, round up to size in top and bottom swages (Fig. 103) and check the size in a hole gauge (Fig. 104). Any surplus length is then cut off with a hot set or hot chisel, working all around the peg to give a neat finish.

To form the square-to-round peg (Fig. 95B), the shoulder positions are marked with centre-punch marks. At a bright red heat, a side set is used to set in the shoulders (Fig. 105). Work around the four sides of the bar, entering the side set a little on each side until just short of the full depth (about 1 to 2 mm short but it will depend on the size of the workpiece). Reheating as needed, forge to a square section using a set hammer with slightly radiused edges. With hand hammer or set hammer remove the corners and finish between top and bottom swages.

Great care is needed to keep these peg ends on centre throughout the forging operations as very little, if any, correction can be made later.

The round-to-square tenon (Fig. 95C) is made in much the same way as that shown in Fig. 95B.

FIGURE 99

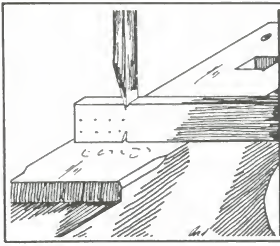


FIGURE 100

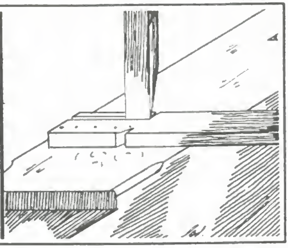


FIGURE 101

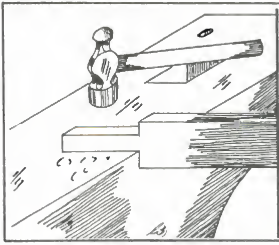


FIGURE 102

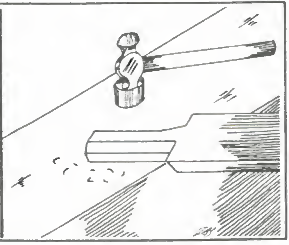


FIGURE 103

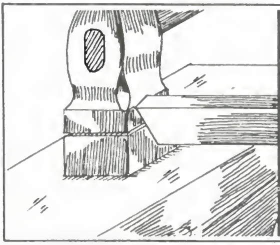
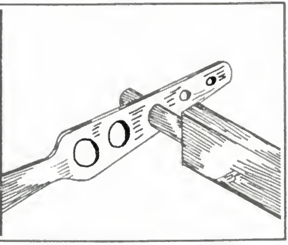


FIGURE 104



Additional care must be taken to keep the side set vertical and at right angles to the centre line of the metal. Set in as for the previous workpiece, then forge to a square section with hand or set hammer. When working with the round section, it is more difficult to turn the work exactly one-quarter of a revolution when setting in the shoulders. If necessary, each of these workpieces can be trued up in a bolster plate or with a monkey tool. Slight errors in the squareness of shoulders or some unevenness can be corrected. Tenons and pegs must easily fit into these tools and smoothly pass through up to the shoulders.

The square-to-square tenon with reinforced shoulders (Fig. 95D) is made by upsetting in the shoulder position and then working with side set and set hammer as before. Again, trueing up and finishing are done in a bolster plate. This type of tenon will be encountered later when making spike-harrow tines. Some smiths prefer to draw-down the ends of pegs and tenons a little and then use a set hammer and the edge of the anvil or the edge of a suitable block held in the tool hole of the anvil. Try both methods and adopt the one you prefer (Figs 107 and 108).

FIGURE 105

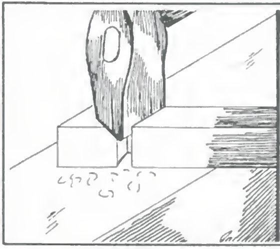


FIGURE 106

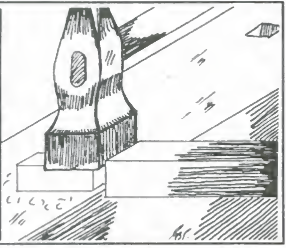


FIGURE 107

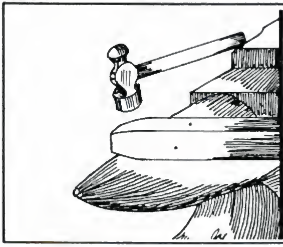
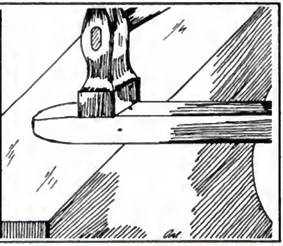


FIGURE 108



11. The easiest way to forge hot and cold sets

FIGURE 109

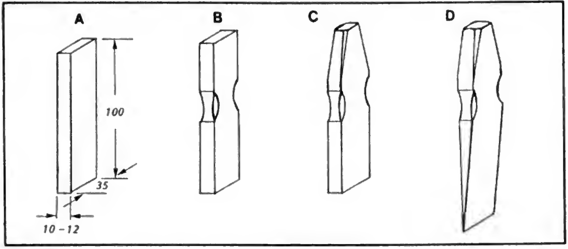


FIGURE 110

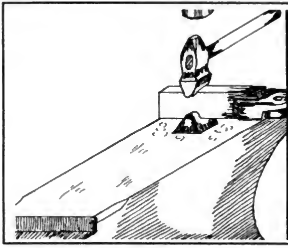


FIGURE 111

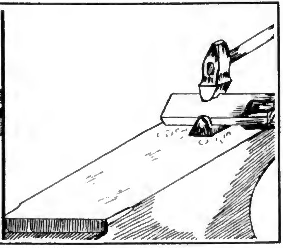


FIGURE 112

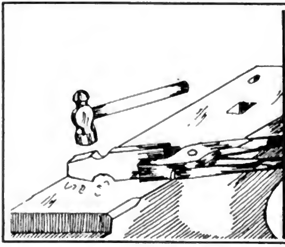
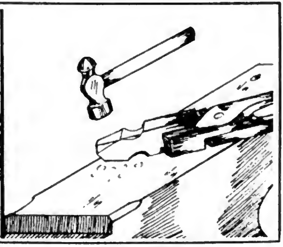


FIGURE 113



Material. Flat vehicle-spring steel, 10 to 12 mm thick, about 35 mm wide and 100 mm long; round-section mild-steel rod 8 to 10 mm in diameter and 1 m long.

Additional tools. Top and bottom fullers of about 25 mm; flatten if desired for a finished surface; vice; file or grinder.

METHOD

Hot and cold sets are important basic smithing tools and are subjected to much heavy work. They must be kept in good condition and replaced when badly worn. Although tools with wooden shafts are considered the best and the most comfortable to use, handles made from mild-steel rod are adequate and even preferred by some smiths. They are certainly the easiest to make and repair. Vehicle-spring steel is chosen because it is usually the most readily available and cheapest source of steel. The tool design is based on flat spring steel for the same reasons. Material from heavy vehicles or, if available, springs off railway rolling stock will provide metal of substantial size for larger tools. For this job, a piece of steel with dimensions similar to those in Fig. 109A will be needed.

Heat just over half the length to a yellow heat, place on the bottom fuller with about 35 to 40 mm overhanging the tool. Quickly position the top fuller, fuller to a depth of 6 to 8 mm (Fig. 110) then and lightly fuller the edges of the recesses formed to remove their sharpness (Fig. 111). True up the workpiece, reheat the short end to a yellow heat and forge it to a slight taper (Figs 112 and 113). This will form the head of the tool, which should be about 15 to 16 mm or a little more than the original thickness of the metal used.

If no grinder is available, the top of the tool should now be rasped or filed flat and then given a slight radius so that hammer blows are concentrated on the centre of the head when in use. If no grinding machine is at hand, the head of the tool can be finished later.

The forged head of the tool is now held in the tongs and the opposite end is heated to a good yellow heat and then forged to a long taper (Fig. 114). On heavy material, if a helper is available, a fuller can be used to speed up the drawing-down operation. A flatter may then be used to improve the surface finish. While hot, the thin end of the job should be cut back to leave a straight edge that can then be filed to the correct cutting angle (Figs 121B and C). Note that the cold set (Fig. 121B) is left thicker than a set for cutting hot metal (Fig. 121C).

Next, heat the tool all over to a red heat and allow to cool in the air, lime, sand or ashes to relieve stresses (normalizing). When it has cooled, hold the job in a vice, find the centre of the handle rod, heat the rod at its centre point to a bright yellow heat and bend it so that it fits snugly into the fullered recesses and close to the sides (Fig. 115). Make sure of this by fitting the handle on to the job and adjusting it if necessary.

Reheat the end plus 80 mm or so beyond the bend to a bright yellow heat, place around the forged set (Fig. 115) and take a full turn tightly around the set (Fig. 116). With light hammer blows settle the rod closely to the sides of the set and bring the unbent lengths together (Fig. 117).

Some smiths like to put a twist in the rod handle close to the head of the set (Fig. 118). This is easily done by holding the rod tightly in the vice about 35 mm away from the set and, with tongs, turning the set to give the tight twist seen in Fig. 118. Cool the heated rod and set in water so that they can be handled.

Make sure that the ends of the rod are of equal length and that the straight lengths are lying close together.

FIGURE 114

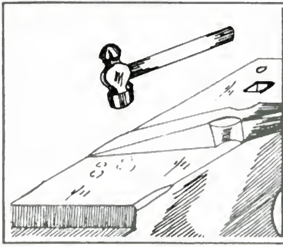


FIGURE 115

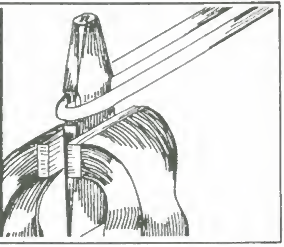


FIGURE 116

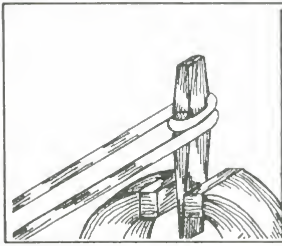
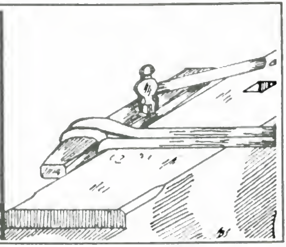


FIGURE 117



Take a full-welding heat on these ends and hammer them together (Fig. 119). After welding, take a longer heat and open out a space next to the weld to form a handle end and an eye from which to hang up the tool in the workshop (Fig. 120). The finished tool is shown in Fig. 121A. The blade sections shown in Figs 121B and C indicate the thicker cold set and the thinner hot set as well as the appropriate angles for the cutting edges.

Hot sets are not usually hardened and tempered because any heat treatment is quickly spoilt when the set comes in contact with hot metal. Keep cooling the set after every two or three blows when in use and repair any damage to it immediately. Keep a fine-toothed file handy for correcting the cutting edge. The cold set must of course be hardened and tempered as for a cold chisel.

Either of the two heating methods may be used and quenching can take place in oil or water. If cracking occurs it will be either because of too rapid a quench, i.e. water instead of oil, or because the metal is worked at too low a temperature when forging. Spring steel must not be forged below red heat or above a yellow heat. At near-welding temperatures the metal breaks down rapidly because of oxidation. After hardening, tempering should usually be at a brown colour.

Tools fitted with rod handles are easy to repair and maintain because they can be readily heated and reforged in order to correct damage. This is of particular importance when the head of the tool has become damaged.

FIGURE 118

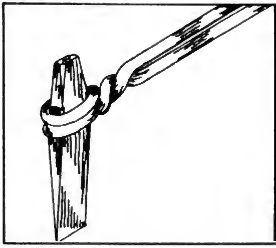


FIGURE 119

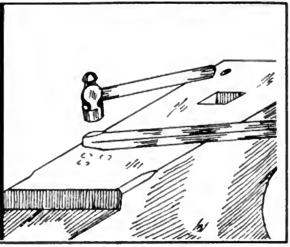


FIGURE 120

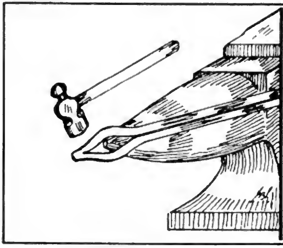
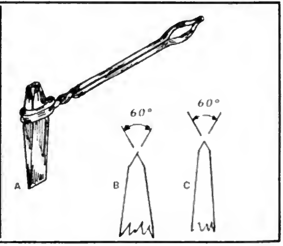


FIGURE 121



12. Forging fullers and tool-hole swages from scrap materials

Material. Flat vehicle-spring steel 10 to 12 mm thick, 35 mm wide and 70 mm long, or as available; scrap railway-line metal.

Additional tools. Top and bottom fullers, about 25 mm; sharp hot set; file; flatter; vice.

METHOD

Fullers are tools important to the smith and particularly so when a helper is available. They are used for rapid, rough drawing-down of heavy sections, for spreading metal in the direction required for making radiused grooves and recesses and, in some cases, for bending material. Ideally they should be made from steel with a carbon content of 0.7 to 0.75 percent. However, in practice it has been found that spring steel, railway-line steel and even some axle shafts provide materials that will make functional tools with a reasonably useable life.

For smaller fullers, the steps shown in Fig. 122 can be followed. The sizes given are for guidance only and depend on the material available and the size of tool required. The head end is formed as for the sets in Job 11 and a rod handle is fitted as in Job 11 after completion. The radiused end is shaped by grinding, filing or rasping while hot. After forging, the tool is normalized

FIGURE 122

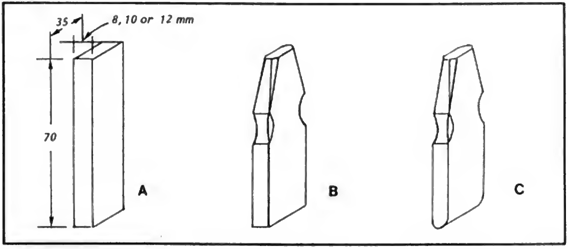
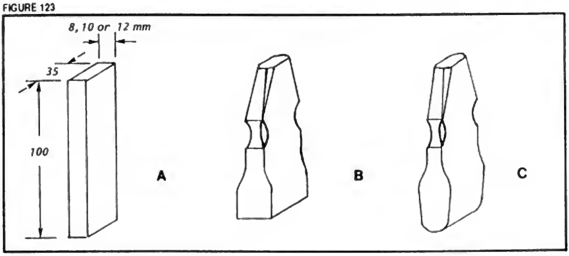


FIGURE 123



and left in this condition. The natural hardness of the metal is sufficient for the working of hot metal. For larger fullers the procedure illustrated in Fig. 123 can be adopted.

The metal is first upset to a little more than the finished thickness of the tool (Fig. 123B). The heat is restricted to the end by cooling with water. Take care not to quench completely any part of the workpiece from red heat. Merely reduce the temperature, leaving the hottest part where the upsetting is to take place. If the steel is completely quenched from high temperatures, excessive hardness will result. The metal will then shatter if struck with hammer blows, creating dangerous flying particles that may damage tools and possibly the anvil face. After upsetting, the head of the tool is formed with fullered recesses as in Job 11. Next, the tool is drawn-down to the finished thickness, radiused as before, normalized and fitted with a rod handle.

Larger fullers can be made from scrap railway-line metal but much more work is involved. If oxyacetylene cutting equipment is available, it is simple to remove the top section of the rail from the web and foot and to cut it into suitable lengths. If the rail is heated to a good red heat and then cooled slowly in lime, sand or ashes, it can be cut with a hacksaw, but this is a laborious process.

Failing other means, heating and cutting with a hot set is the method to use. Slow heating in a large fire with adequate air blast is advised, but make sure that the heat penetrates right through the metal.

Cut off the web and foot of the rail as close as possible to the top section, cutting from both sides. Then cut off a suitable length (Figs 124A and B). Reheat to a good yellow heat and forge the piece to the largest rectangular section possible with neat, straight sides (Fig. 124C). Mark off (Fig. 124C) and cut off the corners, again working from both sides, leaving the piece as in Fig. 124D. Next, fuller and draw-down the head end (Fig. 125A).

The working end is next forged to the finished thickness of the tool and the corners trimmed off the

FIGURE 124

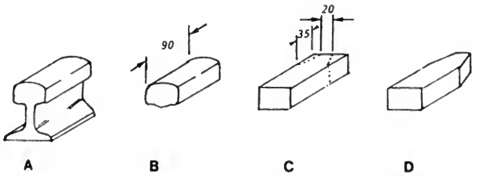
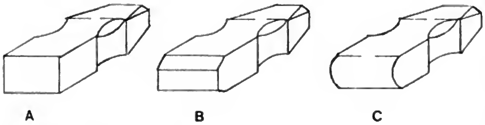


FIGURE 125



working end with a hot set (Fig. 125B). This end is then finished off by grinding, filing or hot rasping to the correct radius. Normalize the tool and fit a rod handle. Again, for hot metalworking, hardening and tempering are not necessary.

Bottom fullers are the counterparts of the top tools and fit into the tool hole of the anvil. Tool holes vary in size as do anvils. In general, tool holes are from about 20 to 40 mm square. Small bottom fullers can be made to fit into the pritchel or punching hole, which may be from about 15 to 20 mm in diameter. For the smaller bottom fullers, flat spring steel can again be used. Production steps are shown in Fig. 126. Sizes are not indicated but can easily be estimated according to tool and anvil size. The height of the tool top above the anvil face should be kept down to 40 or 50 mm.

Straighten a length of spring leaf, mark out the tenon and cut out with a hot set (Fig. 126B). Forge off the corners and round down to a neat fit into the pritchel or punching hole of the anvil. Reheat and cut off about 40 mm from this shoulder, cutting from both sides. Heat the whole to a bright red heat, partially cool to the top of the tool, place into the anvil hole and hammer it down into the hole to square the shoulders and provide a neat seating on to the anvil face. Remove it from the hole and straighten it as needed. Heat and trim off the edges of the top of the tool (Fig. 126C). Round up this end to the correct radius by grinding, filing or hot rasping. Normalize and leave in that condition.

Swages of both smaller and larger sizes can be made from scrap railway-line metal, using part of the web (the middle of the rail) to fit in to the tool hole. The web can be made to fit the hole in only one direction but will work well in practice. The procedure from start to finish is shown in Fig. 127.

By oxyacetylene cutting or by using a hot set, a piece of rail is cut off slightly longer than the size of the tool hole. Cut off part of the web, leaving 25 mm or so of the web attached to the rail (Fig. 127A). The X dimension is the tool-hole size. Using tongs to hold the web, reheat and flatten the piece to get rid of ragged edges from cutting and to make the portion of web a neat fit in to the

FIGURE 126

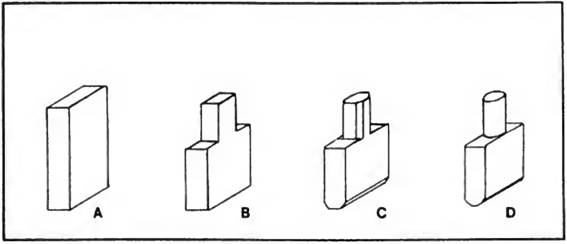
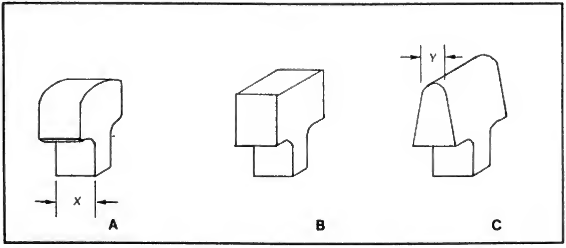


FIGURE 127



tool hole. Reheat, place into the tool hole and flatten (Fig. 128) to seat the tool into position and to give a neat flat top surface.

The job is reheated to a good yellow heat, held in tongs and drawn-down (Fig. 129). Using a fuller speeds up this operation and finishing is carried out with hammer, set hammer or flatter. Heat again and trim off edges with a hot set (Fig. 130) from both sides. By hot rasping, filing or grinding, form the correct radius. Now normalize and the tool is ready for use (Fig. 127C).

For occasional use or in an emergency, shallow fullering can be carried out (Fig. 131). Bend a suitable piece of rod and place it on the anvil face as shown. (The bent ends prevent it from rolling about on the anvil.) A second piece of bar can be used as a top fuller as indicated. This method can be used when making sets and fullers for the first time. It is important to take great care to ensure that hammer blows fall squarely (H in Fig. 131) and exactly opposite the hot metal. If hammer blows are off centre, the top bar may kick up or down violently and injure the smith's hand or wrist.

FIGURE 128

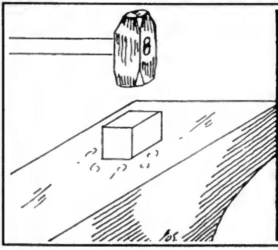


FIGURE 129

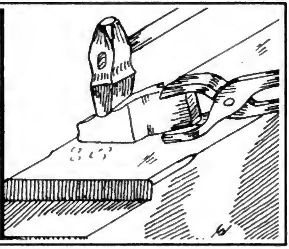


FIGURE 130

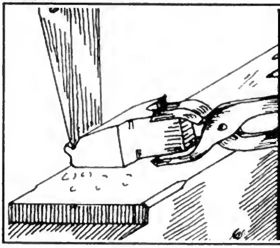
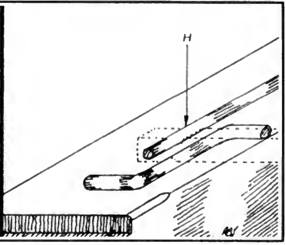


FIGURE 131



13. Forging top and bottom swages

FIGURE 132

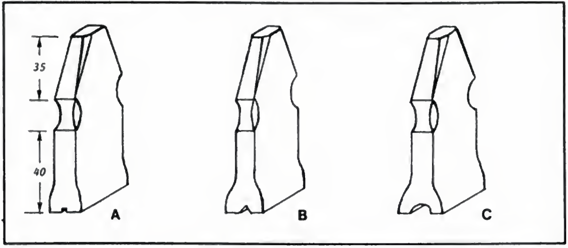


FIGURE 133

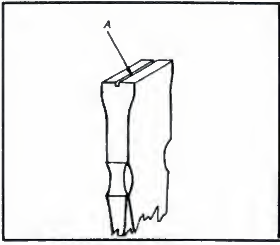


FIGURE 134

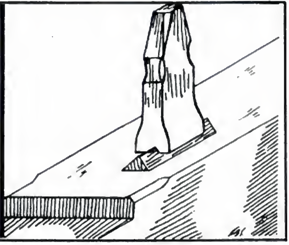


FIGURE 135

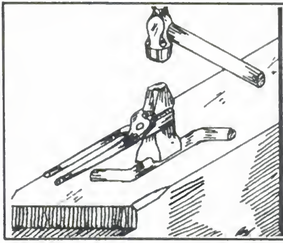
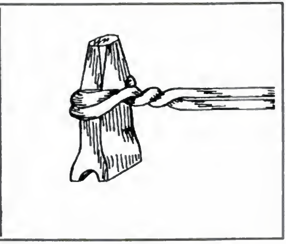


FIGURE 136



Material. Flat vehicle-spring steel as thick as possible; short length of railway-line steel; mild-steel rod 8 to 10 mm for handles.

Additional tools. Hot set; fullers; flatter; hacksaw; short, triangular former (either a softened piece of a three-sided file or a piece of 12-mm square-section steel sawn diagonally).

METHOD

Small top swages can be made in much the same way as top fullers. First form a head as for fullers in Job 12. Upset the opposite end to give enough material for the working end. Mark out the centre line of the upset end and cut a shallow groove with a hacksaw (Figs 132A and 133). Place the short, triangular former on the face of the anvil (Fig. 134) and hammer the heated job squarely on to it in order to begin spreading the metal. As mentioned above, a short length cut from a worn three-sided file in the softened state is ideal here. If this is not available, a short length (60 mm or so) of square-section steel can be sawn lengthwise across its diagonal to serve the same purpose. The topmost angle of this helping piece should be slightly rounded to reduce the possibility of cracking the workpiece when the groove is widened.

After grooving the metal over the former, the job is reheated and worked over a piece of round-section rod (Fig. 135). Start with a rod of lesser diameter than wanted in the finished job. For example, for a swage 10 mm in diameter, the rod would be worked over 8-mm rod followed by rod 10 mm in diameter, which would be worked into the job to half its diameter. For a 12-mm swage, use rods 8, 10 and 12 mm in diameter, gradually working up to the finished size.

The larger the swage, the greater will be the number of different-sized rods used in working up to the finished size.

If you try a short cut and work the job over only the finished size of the rod, excessive upsetting of the work will occur and the resulting groove will always be oversize.

On completion of the forging, the job is again heated and normalized. Any finishing touches can now be carried out by grinding or filing or both. The groove can be cleaned out with a round-section file. All sharp edges should be rounded, particularly at the ends of the grooves. Sharp edges cause indents in workpieces and these may lead to cracks. Again, a rod handle is fitted as before but the handle must be at right angles to the swage groove (Fig. 136).

Larger swages are made in a similar manner but more robust sections of material must be used. Here again, railway-line metal is useful. You can also use large square-section spring tines from cultivators or heavy-section drive shafts from lorries or tractors; the latter are of nickel steels that are very tough although they contain insufficient carbon for hardening and tempering. They will normally stand up to fairly hard work on hot metal.

Whichever is used, a blank similar to that shown in Fig. 137A is required. Sizes are a matter of choice, but enough metal should be available to make a groove 40 or 50 mm long. The shank of the tool should be not less than 25 mm square in section (Fig. 137A) and preferably more than this, perhaps 40 mm for large swages. If railway metal is used, the top section of rail is cut off and a length of 80 to 90 mm is flattened to give a rectangular section as big as can be readily worked from the blank. After flattening, the ends should be neatly squared up on the face of the anvil. Shoulder with fullers and draw-down the shank to a square section.

FIGURE 137

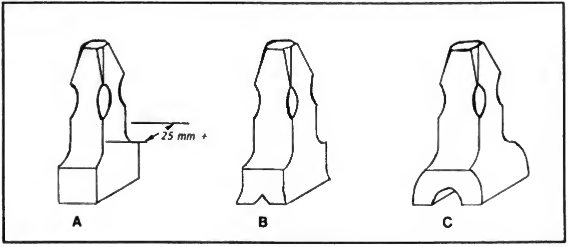
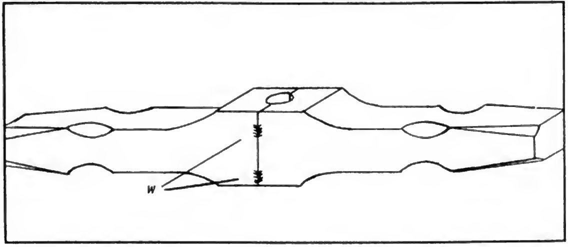


FIGURE 138



The head of the tool is next tapered and fullered recesses are made to accommodate the handle. Note that when using square sections the corners only are fullered fairly deeply. The centre of the face can be then marked and a shallow hacksaw cut made (Fig. 133). The swage groove is again worked as described earlier (Figs 137B and C).

If electric-arc welding is available, some swages can be made in pairs by tacking the pieces together (Fig. 138). A pilot hole is then drilled (Fig. 38), and this is followed by the finished-size drill. The job is then broken apart and the weld spots (W in Fig. 138) are filed or ground off.

Bottom swages are required to match the top tools. Material requirements are similar. A useful swageing tool is illustrated in Fig. 139, showing a number of swageing grooves contained in one tool. The tool is a flattened piece of steel such as railway metal, with one end drawn-down to fit the tool hole of the anvil (A in Fig. 139). A right-angle bend has been made, leaving 25 to 30 mm to fit the tool hole. The remainder, about 80 mm, is carefully flattened while hot to lie closely on the anvil face when the shank is in place in the tool hole. Grooves can now be fullered into the tool up to about 10 mm in size. Start with a smaller fuller than the required finished size and complete the grooves with rods of the correct diameter driven in to half their diameter. Finally, true up the work and clean up by grinding, filing or both.

Suitable blanks for larger bottom fullers can be made as for the bottom fullers shown in Figs 127 and 128. At a good yellow heat, the block is forged flat while in place in the tool hole. Next, square up and flatten the sides. Grooves can again be fullered in (Fig. 140). Again, start with a small fuller and gradually work up to the required size. The depth of grooves can be checked with a straight-edge and rule (Fig. 140).

FIGURE 139

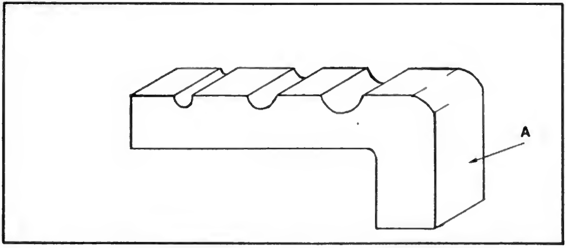


FIGURE 140

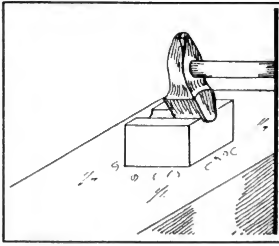
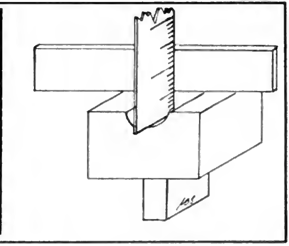


FIGURE 141



14. Forging set hammers and side sets

Material. Square-section carbon steel, spring steel such as large spring tines from cultivator or railway-line metal.

Additional tools. 10- and 20-mm top and bottom fullers, slot punch and drift.

METHOD

The simplest of set hammers is shown as B in Fig. 142. The dimensions are for guidance only and can be varied to suit the metal available and the requirements of the smith.

Set-hammer faces are usually 25 to 30 mm square. For handles made from steel rod, the top or head of the set hammer is drawn-down as for previous tools. Fullering to accept the rod handles is carried out on the corners only. After forging, the tool is normalized and finished by grinding or filing with each edge slightly rounded (Fig. 142B). If you want to carry out hardening and tempering, bring the face end to red heat and quench in oil. Next, clean and polish the face and heat up the opposite end slowly in the fire while keeping the face uppermost. Heat will be conducted to the hardened end. When a dark-brown oxide colour is seen, quench it in water.

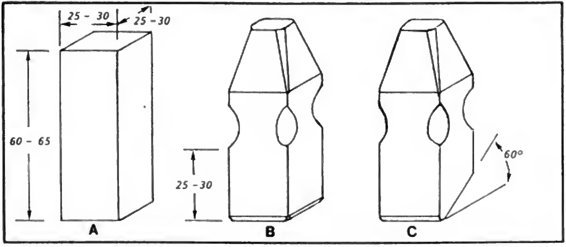
A side set is made in a similar manner with the face angled at approximately 60 degrees (Fig. 142C). Side sets are used for the rapid setting-in of shoulders for tenons.

Although adequate for most work, the set hammer with a handle made of metal rod is sometimes difficult to use with precision. A tool fitted with a wooden handle gives the smith a better grip and thus better work.

The eye is made by punching a slot hole and then opening this out to accommodate the wooden handle. A slot punch and a drift are required (Figs 144A and B). The slot punch is like a very small fuller, while the drift is a piece of round-section steel drawn to a taper as shown and finished to section by filing or grinding. These tools should be well-made and kept ready for use when other wooden-handled tools are to be made.

The slot punch is made from flat spring steel in the same manner as the fullers previously described. The working end can be 25 to 30 mm wide by 2 to 3 mm thick. If possible, the drift should also be from spring steel although axle-shaft steel will suffice. The drift is made by drawing-down to a tapered round-section point and then flattening. The 80-mm tapered length is given as a guide; it may be longer. If the section shown occurs about halfway along the taper, a proportionately larger section will occur farther along this taper, and it can be used for making larger eyes in other tools. Dimensions are not generally critical but should be somewhere near those indicated.

FIGURE 142



Forging is easier if a hand length of material is available. First mark off the centre of the workpiece on both sides and then mark the position of the hole, leaving enough material to form the head, about 35 to 40 mm from the end to the start of the hole. Centre-punch these positions. Take a good yellow heat in the position of the hole and carefully punch from both sides with the slot punch. The punch must be kept upright and cooled frequently. After the hole has been started, a little coal or coke dust sprinkled in to the hole will keep the punch from binding in the work.

When the slot hole is completed (Fig. 145), the hole is opened out with the drift (Fig. 146) but not to its full size. If you have trouble getting the drift to enter the work, an upsetting action (Fig. 150) will open the slot a little and make the job easier. At a good yellow heat,

FIGURE 143

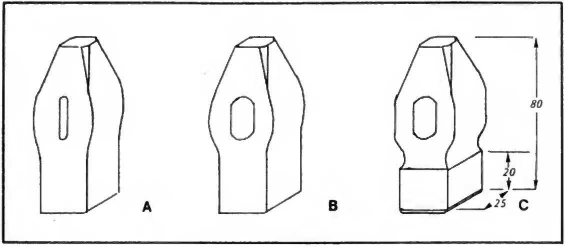


FIGURE 144

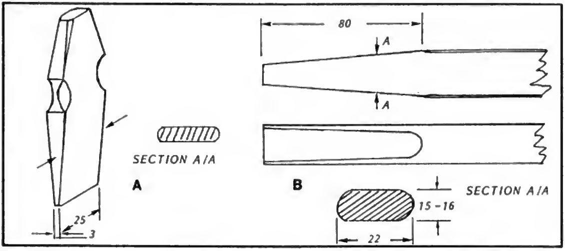


FIGURE 145

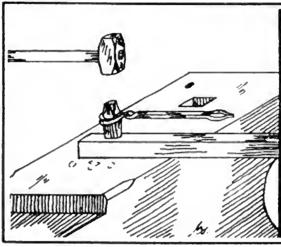
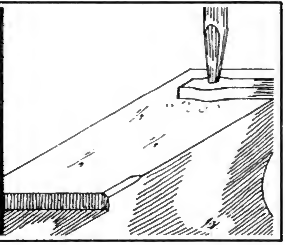


FIGURE 146



forge the head of the tool (Fig. 147), then trim all around with a hot set. This will make cleaning up the head easier.

Heat again to a yellow heat and fuller below the eye (Fig. 148) with a fuller of about 10 mm to a depth of 6 mm. This operation can be omitted, but the fullering makes it easier to site the position of the edge of the tool when in use. While at a bright red to yellow heat, drive in the eye drift to the correct depth from each side in turn to bring the eye to the required size and to make the eye taper toward the centre from each direction. While the drift is in position, slightly flatten the sides of the eye. Leave the maximum possible thickness of material around the eye to withstand hammer blows.

The formed tool is next separated from the bar by cutting with a hot set (Fig. 149). Cut evenly and squarely from all four sides. At this stage, if a good rough file or rasp is available, heat to a yellow heat and rasp off much of the unevenness from the cut face. Normalize it, and when it is cold either file or grind it to a flat face with slightly radiused edges.

On hot metal the tool will work well in this state, but it can be hardened and tempered. To do so, heat the face end to a dull red and quench it in oil. Clean and polish the face, heat up the drift or preferably another piece of steel tapered to fit the eye, place the heated drift or other piece in to the eye and watch for the oxide colours. As soon as dark brown to blue begins to appear, requench it in water.

Fit a smooth, comfortable wooden shaft about 300 mm long. The handle should be a firm fit. Most smiths, however, do not wedge these into place for anvil tools. Use your own judgement, but remember that if the handle is not wedged, the hammer must be watched closely or the head may fly off while you are using it.

FIGURE 147

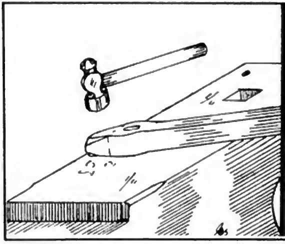


FIGURE 148

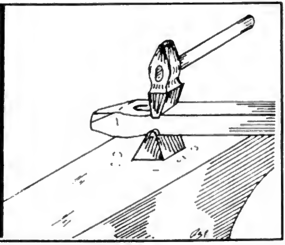


FIGURE 149

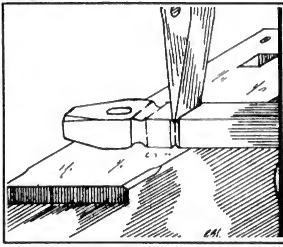
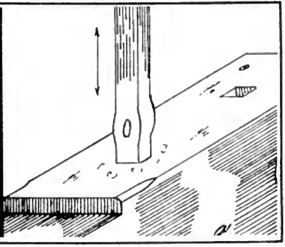


FIGURE 150



15. Forging a flatter

Material. Top section of railway-line metal, spring steel such as from a large broken cultivator tine or a piece of old motor-vehicle axle shaft; about 1 m of mild-steel rod, 8 or 10 mm in diameter.

Additional tools. Tongs adapted or made to fit across the face of the flatter; swage block; 20-mm top and bottom swages; grinder or a good second-cut file; cold chisel.

METHOD

If a swage block is available, bevel a square hole to accommodate the metal section used (Fig. 152). This is easily done with a sharp cold chisel and a file. In some cases the tool hole of the anvil will be large enough, and this is bevelled.

The metal should be forged and neatly cut to about the dimensions in Fig. 151A. The dimensions of your workpiece will depend on the size of flatter required. Next, bring one end of the workpiece to a bright red or yellow heat, restrict the heat to within about 30 mm of the end by cooling, and upset (Fig. 153). Upset until, when the cool end is placed in the hole in the swage block or anvil, about 25 mm stands up above the level of the hole. Next, take a longer bright red to yellow heat and forge in the handle recesses with top and bottom fullers (Fig. 154).

Now bring the upset end to a bright red or yellow heat, place the work in to the hole and flatten it (Fig. 155). A fuller can help spread the metal in the directions required. Flatten until 8 to 10 mm of the metal stands up above the face of the anvil or swage block. Flatten as

FIGURE 151

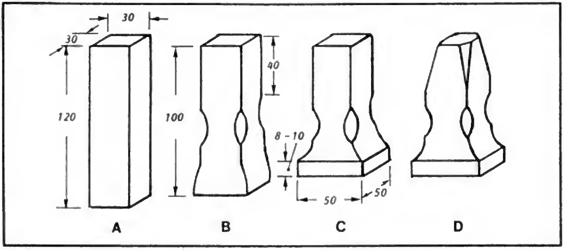


FIGURE 152

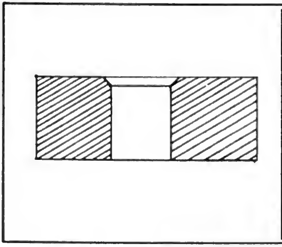
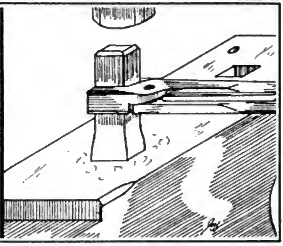


FIGURE 153



smoothly as possible with sledge- and hand hammers and use another flatter if available. The better the finish obtained, the less filing or grinding will be needed later.

With well-fitting tongs, reheat the flattened end and square up the face (Fig. 156). Again, use a flatter if available. It will probably be necessary to return the job to the swage block or anvil hole from time to time to eliminate distortion of the face. Finish up as square and flat as possible.

Next, with properly fitting tongs, reheat the opposite end of the job and forge the head end (Fig. 157) to give the shape shown in Fig. 151D. Bring the whole job to a good red heat and cool it in sand, lime or ashes to soften. When cool, grind the edges and faces flat and square. If no grinding wheel exists, this work must be carried out with a file. Next, remove all sharp corners and edges and, if the tool is for fine work such as carpenters' cutting tools and knives, the face should be polished. If you want to harden this tool, heat the face slowly to a dull red heat and quench in water by placing the other end of the tool downwards into the water first. This will give a more even rate of cooling to the face. If the face enters the water first there is a danger of cracking because the edges of the face cool more rapidly.

To temper the piece, polish the face and then place the head of the tool into the fire with the face uppermost. Observe the oxide colours and when brownish blue is reached (if you are using spring steel), requench it. During this tempering do not allow the head to reach red heat. If this happens, the head will be hardened by the second quench, damaging the hammer face, and it is likely to crack and splinter during use.

A rod handle can be fitted as described in Job 11. You must always keep in mind that a flatter is a finishing tool and is not intended for heavy forging work. Kept in good condition, it enables good finishes to be made when required. If metal other than spring steel is used, some experimenting with hardening and tempering will be needed. A good file should just be felt to be scratching the tool, but it must not file easily.

FIGURE 154

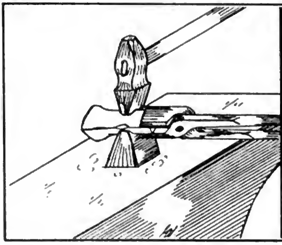


FIGURE 155

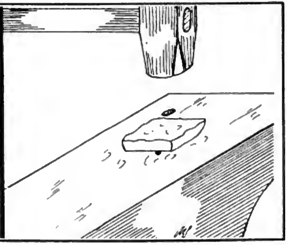


FIGURE 156

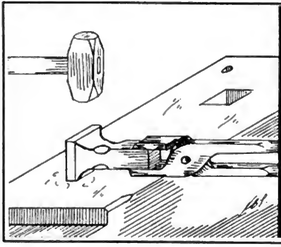
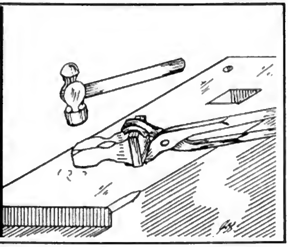


FIGURE 157



16. Forging a simple ball-peen hammer

FIGURE 158

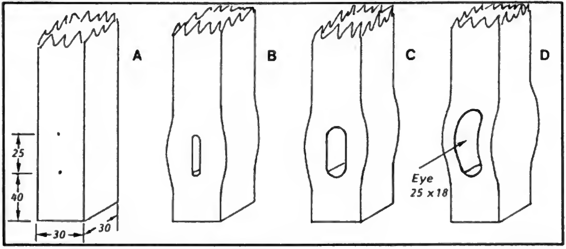


FIGURE 159

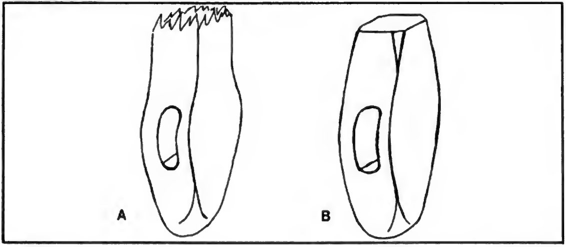
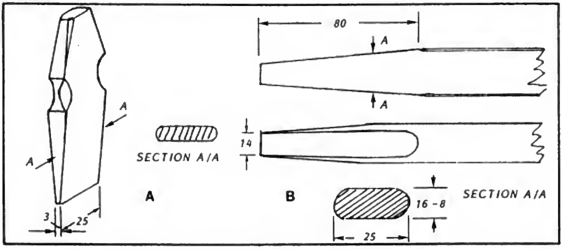


FIGURE 160



Material. Railway-line steel; motor-vehicle axle shafts (half shafts); square-section spring steel or mild steel if treated as in Job 18, or even a piece of old ox-plough beam of solid section.

Additional tools. Slot punch and drift (it is best to have a drift of about 200 mm for ease of handling); old bastard file or rasp; grinder, if possible.

METHOD

In some forging operations a ball-peen hammer is useful. The easiest type to make is that shown in Fig. 159B. If you look back at Job 14 (the set hammer), you will see that the eye is left with as much metal as possible around it in order to withstand being hit with powerful hammer blows. In hand hammers, this thickness of metal is not needed.

It is important that the eye taper toward the centre from both sides so that the shaft can be securely wedged into position. To do this, the eye drift is tapered as shown (Fig. 160B). The material size depends upon the weight of hammer required, but for practice a 30 x 30-mm square is suggested.

If possible, use a hand length of material. This is easier to handle than a shorter length held in tongs. Mark out as in Fig. 158A with prominent centre-punch marks on both sides of the piece. Take a yellow heat and slot punch from both sides as in Job 14. Reheat and cool the end slightly, and upset to open the eye as in Job 14.

While the job is hot, hammer in the drift quickly from alternate sides but not to its full depth. Leave about 15 mm of the tapered end of the drift still to go. Reheat to a yellow heat and flatten the sides of the eye on to the drift (Fig. 161). Work alternately from each side. As the flattening proceeds, the drift is driven farther in to the eye, again working alternately from each side until the full size and correct shape of eye are obtained.

When the eye is correctly formed, reheat the end and forge (Fig. 162) to a square section, then remove the corners to give an octagonal section about 22 mm across the flats. With a sharp hot set, cut off any surplus material to leave a length of 35 mm from the rim of the

FIGURE 161

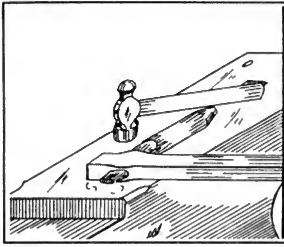


FIGURE 162

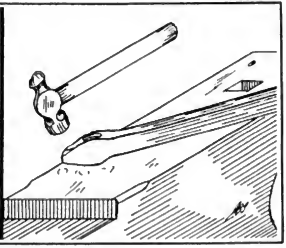


FIGURE 163

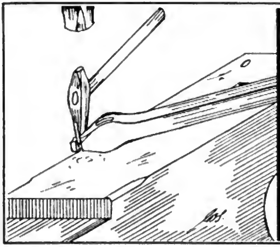
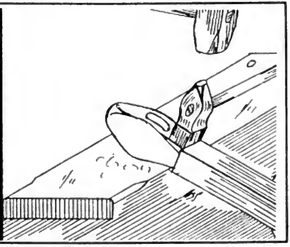


FIGURE 164



eye (Fig. 163). Cut all around the piece equally from all sides. This will leave a slightly pointed end that will require little finishing to give a neatly radiused shape to the ball-peen. Final finishing of this end can be carried out by grinding or filing. If a good rasp or old bastard file is at hand, most finishing can be carried out by quickly filing or rasping the job while at a good yellow heat, the final finish being done when it is cold.

If any deformation of the eye has occurred during the drawing-down and cutting, this should be corrected by gently tapping the drift back into the eye from either side. Next, with either hand hammer or set hammer (Fig. 164), the face end of the hammer head is set down over the edge of the anvil and drawn-down to slightly less than the original 30 mm, after which the corners are slightly flattened. The distance across the flats should be about 28 mm.

With a sharp hot set, cut the hammer head off the bar, leaving the face as flat as possible. If the set you use is sharpened from one side only, this will help to keep the face flat. Again, this face may be rasped while hot. Reheat to red heat all over and allow the head to cool in sand, lime or ashes. When it is cool, finish the face with a grinder or file.

If the hammer is made of spring steel, it can be hardened and tempered by heating to a dull red heat, holding it with tongs through the eye and quenching the face and the peen in turn in oil. They should be repeatedly quenched one after the other until the eye is quite cool (the eye must never enter the oil). Then the whole job can be finally cooled.

Clean up both face and peen, heat a drift to a bright red heat and place it firmly in to the eye. Heat will be conducted from the drift to the hammer head. Watch for the oxide colours to appear. When a dark brown, almost blue, is seen, quench the faces in water in the same manner as above. It is likely that the colours will appear on the peen end first. Look out for this and quench that end while waiting for the colours to appear on the other, then quench alternately as before.

If railway steel is used for the head, adopt a similar technique but quench it as soon as a light brown appears. If the job is made of motor-vehicle axle shaft, quench it in oil from a dull red heat. If mild steel is used, see Job 18. Finally, clean up the face and peen with a fine grinding wheel or emery cloth. Fix a good wooden shaft to fit the user's hand. It should be about 500 mm long for anvil work.

17. Forging an engineer's ball-peen hammer

Material. Old axle shaft (half shaft) from motor vehicle or tractor (even a front stub axle will do); a piece of railway-line steel; an old plough beam; 25-mm round-section mild steel.

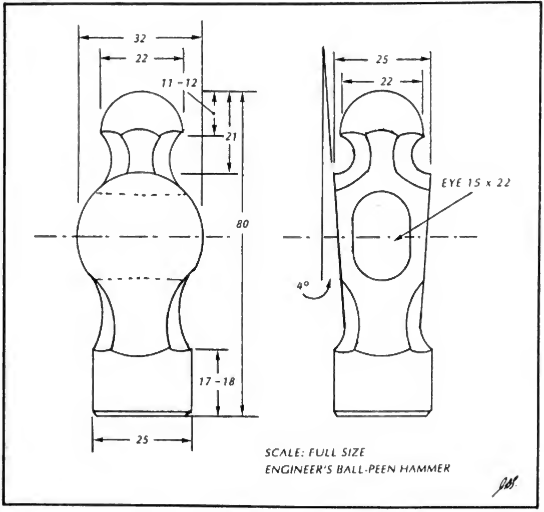
Additional tools. Top and bottom fullers about 25 mm; eye drift as for Job 16; slot punch made to suit, about 22 mm along the edge; set hammer; flatter; sharp hot set; top and bottom swages of 22-mm diameter.

METHOD

The most popular ball-peen hammer is the so-called engineer's ball-peen hammer. It is more difficult to make than the hammer described in Job 16. It is a more sophisticated tool and is useful to craftsmen other than blacksmiths. Figure 165 shows a hammer full size and of dimensions suitable for practice. It weighs about 200 g. Larger and smaller ones can be made in the same way. The dimensions given are not critical but, if followed, they will give a well-balanced tool.

This job can be done using round- or square-section steel, but round is easier to work with. Square gives more material around the eye but requires additional work in rounding the ends. Axle steel 25 mm in

FIGURE 165



diameter or larger is as good a material as any for this job. Other types of scrap require considerable forging to prepare the blank. Mild steel is the easiest to work but needs to be treated, as in Job 18. If possible, use a hand length of material, leaving tongs to be used only for the last operation.

Mark off as in Fig. 166A with prominent centre-punch marks. Heat to a bright red to yellow heat and punch a slot hole as described in the previous job. Upset a little to open the hole. Drive in the drift alternately from each side of the hole but not to its full depth. Fuller (Fig. 168) to give the form shown in Fig. 166D. Use the 25-mm top and bottom fullers for this with the metal at a bright red heat. The fullering need be only 3 to 4 mm deep. Notice that the fullering should indent the metal to a square section as close to the eye as possible (Fig. 166D). These four corners are then fullered to give an eight-sided section.

Next, at a bright red heat and with the drift in the eye, hold the work over the rounded edge of the anvil and at an angle to the anvil face (about 4 degrees). Flatten the

FIGURE 166

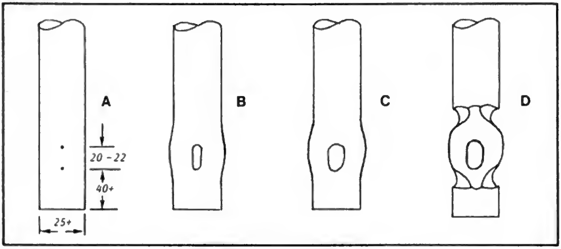
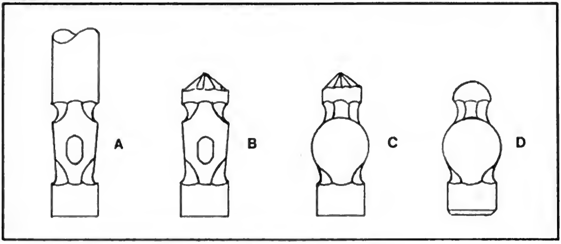


FIGURE 167



sides of the eye (Fig. 169). Work alternately from each side, spreading the metal to give the form it will eventually take when cut from the bar (Figs 167B and C).

The drift will also need to be introduced from alternate sides in turn, driving it in a little farther each time as the metal is spread until the full size of the eye is reached. It is important to keep the work as straight as possible during this operation. If you need to, you can do a little more fullering now to finish that part of the work neatly.

Reheat to a bright red heat, slightly cool the eye to prevent bending and cut off the job from the bar with a sharp hot set (Fig. 170).

Select or adapt a pair of tongs that will fit well over the face end of the job, bring the ball-peen end to a bright red heat and reduce its diameter to 22 mm (Fig. 171). This can be finished in top and bottom swages if they are available. Bring to a red heat all over and cool slowly. The face and ball peen are finished by grinding or filing to the form shown in Fig. 167D. Notice that sharp edges are removed from the flat face.

Hardening is carried out as in Job 16. If mild steel is used, see Job 18. When a neat and clean forging has been produced, it is worth cleaning up all over with a wire brush. Some additional filing of the eye may be done to give a pleasing appearance.

FIGURE 168

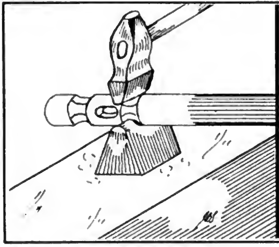


FIGURE 169

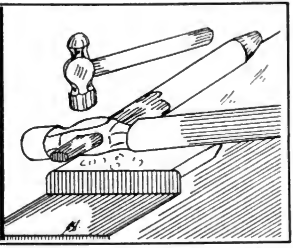


FIGURE 170

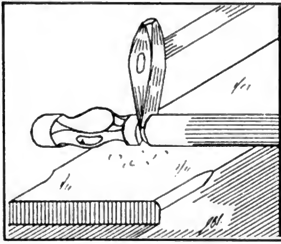
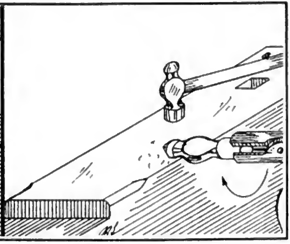


FIGURE 171



18. Some applications of cast iron as a hard-facing material

Material. Low-carbon (mild-steel) workpiece, cast iron welding rod (not electrodes used for welding cast iron) or pieces of broken cast iron; powdered borax or a commercial cast-iron or bronze-welding flux.

Additional tools. Grinding equipment if this work is performed on tools.

METHOD

Where steel suitable for the making and repairing of ploughshares, ridger points, landsides and similar equipment is not available, the smith often has to use low-carbon steels. They may also have to be used in toolmaking. For several kinds of tools the wearing life of parts subjected to abrasion can be prolonged by refacing the most affected parts of jobs.

Where there is a lack of suitable steels, there is almost always a lack of modern hard-facing and wear-resisting materials. Even when available, they are often too expensive for use in rural areas of developing countries. In addition, they usually require electric-arc or oxyacetylene welding equipment, which again is not always available. Nevertheless, given a good blacksmith's fire, flux, cast iron and a little practice, cast iron can be applied to low-carbon steels that, when quenched from high temperature, will give a very hard surface. Although not as effective as the use of modern alloys, this treatment does prolong the life of wearing parts and allows some tools to be made from low-carbon steels.

The application of cast iron is far from a new idea. It has been used by smiths for many generations and was of prime importance when only wrought iron and pig or cast iron were available. The process is made possible because of the difference in the melting temperatures of wrought iron and low-carbon steel and that of cast iron. Wrought iron melts at more than 1 500°C, mild steels at about 1 420°C and cast irons at 1 280° to 1 350°C, depending on how much carbon is present in the iron. Cast iron passes through a "pasty" stage when melting and does not become really fluid until a fluxing agent is applied.

If cast-iron welding rod is used, the application is fairly easy. If broken pieces of cast iron are used, they should be of fairly thin section. Pieces from old cylinder blocks or cylinder heads of motor vehicles are quite good. Pieces need to be of sufficient length to be held in tongs without overheating. Flux should be placed close to the fire, perhaps on a metal dish.

The workpiece is heated at the part to be treated to a bright yellow or nearly white heat. While this heating is taking place, the cast iron is also heated. As the cast iron

FIGURE 172

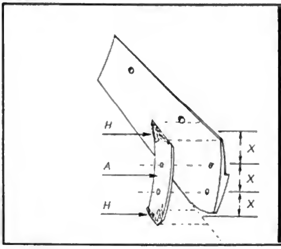
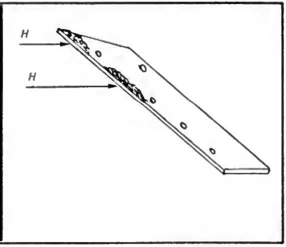


FIGURE 173



nears the melting point, it will sag toward the fire. Dip the cast iron in to the flux, reheat a little and then apply it to the job by rubbing it on to the heated part of the work. The cast iron can be spread fairly easily on to the work and a buildup will be observed. Sufficient thickness is 1 to 2 mm. More can be deposited if needed. During this operation the work remains in the fire. Allow it to cool to a dull red heat and quench it in water. No additional work is required on jobs such as those shown in Figs 172 to 175.

For hammers and suchlike only the faces are treated in turn and, after quenching, these need to be ground smooth. It is a good idea to practise this operation on a scrap piece of mild steel with cast iron and flux before attempting it on an important job. You will learn by experience the best angles to hold the job in the fire and how to judge temperatures.

Although cast iron is a very brittle material, it is so modified during this operation, as well as being backed up by the tough mild steel, that it can be used with confidence on hammer faces without fear of cracking.

Figure 172 shows one method of repointing a ploughshare. Holes are drilled or punched at equal centres as shown at XXX. These holes need to be only about 8 mm in diameter. A piece of mild steel about 40 x 4 mm and of sufficient length is curved to match the share and drilled or punched in the same way. The working end and its opposite are hard-faced. The piece is riveted into position and will give good service. When it is worn, the rivets can be removed and the piece reversed and used again. (H in the figures indicates the position of hard-facing.)

A replacement landside can be treated at the points of greatest wear (Fig. 173). Ridger body points and coulters can also be made or repaired and treated (Figs 174 and 175). Many more ways to use the technique can be found. If a smoother finish is required, a little light hammering can be carried out on the deposit at red heat to smooth the surface before quenching.

It must be stressed that only wrought iron or mild steel can be treated in this way.

FIGURE 174

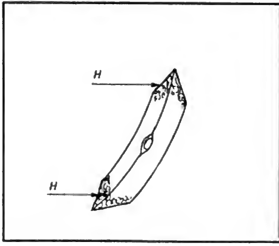
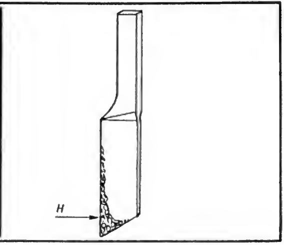


FIGURE 175



Glossary

Alloy
mixture of two or more metals

Anneal
to heat and then cool to achieve maximum softness

Antimony
element alloyed with lead and tin to produce soft solder

Anvil
shaped iron or steel block with hardened face upon which metal is forged

Ash
residue after fuel has been burnt

Ash
wood often used for tool handles, particularly in Europe

Beak
the cone-shaped end of the anvil

Bellows
air pump used for supplying air blast to the forge fire

Bend
angle or curve formed in metal

Blast
air supplied to the forge fire by bellows or by other means

Blast pipe
pipe conducting air blast to fire (also called tuyere)

Blow
to supply fire with air or to hit with a hammer

Bolster
steel plate with variously shaped holes to aid in the forging of shoulders

Bolt tongs
specially shaped tongs to hold bolts and rivets, etc.

Borax
chemical used as a fluxing agent when welding

Bosh
blacksmith's tank to supply water for cooling work or the blast pipe

Carburize
to heat iron in the presence of a carbon-rich material with air excluded to increase the surface carbon of the iron

Charcoal
black residue of wood after smothered burning, used as forge fuel

Cleft
cut or slot in metal often used as a weld preparation

Clinker
the residue of burnt fuel in the blacksmith's fire

Coal
fossil fuel used in blacksmith's fire

Coke
coal processed to remove gas and used as forge fuel

Dies
shaped blocks of metal between which metal is forged; also tools for cutting external screw threads

Dog
mechanical device for holding or gripping something

Drift
short metal rod used to size or shape punched holes

Eye-bolt
bolt with a looped head

Fan
mechanical device used to produce air blast

Felloe
section of a wheel rim

Flatter
flat-faced swage

Flux
chemical agent used to dissolve oxides on metal to be welded

Forge (n.)
blacksmith's workplace

Forge (v.)
to shape hot metal by hammering, by hand or machine

Former
device for bending sheet metal; also template around which an article is formed

Fuller
shaped bottom tool or shafted top tool used to produce grooves in metal

Glow
to give off light, i.e. red, yellow or white heat

Gouge
chisel-like tool with a curved cutting blade

Grind
to remove metal with an abrasive such as a grinding wheel

Haft
shaft or handle of tool

Hammer
shafted tool for striking metal and tools

Hand length
length of metal that can be handled without tongs

Harden
to heat-treat steel to achieve maximum hardness

Hardness
ability of one metal to scratch another

Hardy
cutting tool fitted to tool hole of anvil

Heat
to make hot or the degree of hotness, i.e. red, yellow or white heat

Helper
blacksmith's assistant

Incandescent
glowing with heat, giving off light

Iron
silvery grey metallic element; when mixed with carbon, it changes to steel

Mandrel
Shaft to which work is fixed while being turned

Metal
metallic elements: iron, copper, tin, etc. or mixtures of such

Mild
mild steel is that which is soft and malleable

Monkey tool
block with holes used in forging shoulders

Normalize
heat-treat to remove stresses and to bring the metal to its normal condition

Notch
prominent nick or groove in metal

Oxide
metal combined with oxygen; it forms rapidly at high temperatures

Peen
face of hammer other than flat, such as cross-peen

Pintle
hinge peg

Plastic
capable of being moulded or shaped

Pritchel
punch for opening holes in horseshoes; also describes anvil hole used for punching

Punch
shaped steel tool for making holes in metal

Reins
the handles of blacksmith's tongs

Rivet (n.)
metal pin passing through holes with a head formed on ends

Rivet (v.)
to fasten parts together with a rivet

Scale
oxide on surface of metal after heating

Scarf (n.)
metal notched as a preparation for welding

Scarf (v.)
to notch; to unite by a scarf joint

Set
tool to be hit with a hammer

Shaft
length of bar or a handle for a tool

Shears
lever-operated tool for cutting metal

Shoulder
angle forged in metal and resembling human shoulder

Snap
tool for forming rivet heads

Soften
to remove hardness by heat treatment

Steel
combination of iron and carbon

Stocks
supporting framework

Strike
to hit with a hammer

Swage
shaped top or bottom tool, usually with half-round groove, to form metal

Swage block
heavy cast-iron block with shaped holes and grooves

Tang
projecting point by which a blade is held firm in handle

Temper
to reduce the degree of hardness by heat treatment

Tenon
end of bar drawn-down to a square or rectangular section

Tommy-bar
short bar for use with box-spanner

Tongs
pincers for holding metal during forging and other operations

Tuyere
pipe to conduct air blast to fire

Upset
to make metal shorter and thicker

Vernier
small movable graduated scale for indicating parts of divisions on a graduated instrument

Vice
device with two jaws that is fixed to a bench to hold workpieces

Weld
in blacksmithing, to join metals by heat and pressure or by fusion

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